THE UNIVERSITY OF ALBERTA

MDes FINAL VISUAL PRESENTATION

By

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A THESIS

SUBMITTED TO THE FACULTY OF GRADUATE STUDIES AND RESEARCH IN

PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE DEGREE OF

MASTER OF DESIGN

IN

VISUAL COMMUNICATION DESIGN

DEPARTMENT OF ART AND DESIGN

EDMONTON, ALBERTA

FALL 2008

THE UNIVERSITY OF ALBERTA

RELEASE FORM

NAME OF AUTHOR: PIOTR MICHURA

TITLE OF THESIS: FINAL VISUAL PRESENTATION

DEGREE FOR WHICH THESIS WAS GRANTED: MASTER OF DESIGN

YEAR THIS DEGREE WAS GRANTED: 2008

THE UNIVERSITY OF ALBERTA

FACULTY OF GRADUATE STUDIES AND RESEARCH

The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies and Research, for acceptance, a thesis entitled:

Final Visual Presentation

Submitted by Piotr Michura in partial fulfillment of the requirements for the degree of Master of Design.

Designing an open framework for creating, using and studying diagrammatic representations

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Visual Communication Design
Master's Thesis Report
Department of Art and Design
University of Alberta

Fall 2008

ABSTRACT

The objective of the thesis research was to develop an open framework that could serve as an aid for creating, using and studying diagrammatic representations.

Diagrams are a unique means of visual communication. They have potential as efficient tools to map and manipulate complex, multi-connected structures of data to record, understand, communicate information as well as build new ideas and concepts.

An overview of approaches to study diagrammatic representations in relevant literature is presented, followed by a series of interviews with experts from different disciplines talking about their understanding of issues connected to diagrams. As a result, the concept of diagrammaticty is introduced, which is a working term encapsulating circumstances that can contribute to diagrammatic qualities of visual representation. Finally the framework is proposed based on an aspect-factors schema, which is an attempt to operationalize the diagrammaticity concept. The framework consists of aspects, which offer means for describing how diagrammatic representation works, and factors, which structure information about the situational context in which the representation is involved. The framework's advantages are discussed and areas of further study identified.

CONTENT

1. INTRODUCTION

One aim of this thesis project was to study diagrams as a specific type of graphic representation in the context of visual communication design. At first, this related exclusively to visual communication design education, but it became clear that the outcomes could also be useful for design practitioners and researchers.

This study included:

- defining what a diagram is;
- understanding how diagrams can be understood across different disciplines; and
- identifying and describing relevant terminology.

Additionally the project was aimed at laying a foundation for structuring the knowledge about diagram creation, use and study. The form of a conceptual framework proved to be useful for this purpose.

The area of research that could be associated with diagrams has not been developed yet to the extent that would enable a cross-disciplinary, unifying theory of diagrams to be formulated. The methodical studies on diagrams, often referred to as diagrammatics, have only begun to receive attention from a broader research audience. This approach could be estimated at less than twenty years old (Kulpa, 2004).[1] Today, it would be more appropriate to refer to the area of diagram research as a field of studies rather that a discipline. The field of studies consists of "a repertoire of interests that is not as yet completely united" in contrast to the discipline, which has "its own method and precise objective" (Moriarty & Barbatsis, 2004, p. xiii). Moriarty and Barbatsis recalled these issues in the context of visual communication discussing its status as a field of studies. Most of the visual communication field characteristics can also be repeated keeping in mind the field of diagram studies:

- its transdisciplinary roots are hard to trace in logical, hierarchical order. Instead it is "scattered and fragmented," a rhizome-like organization;
- there is no unifying theory, but a set of interrelated concepts taking their origins from a variety of other fields and disciplines; and
- its identity is built on the process of cutting across traditionally distinctive fields and disciplines. (Moriarty & Barbatsis, 2004, p. xi-xiii).

1. This estimation follows the argument provided by Kulpa (2004, p. 4), that the first symposium exclusively dealing with diagrammatics took place in 1992. It was a 1992 AAAI Spring Symposium.

The field is thus populated by researchers coming from other fields, realizing their own agenda. Blackwell and Engelhardt (2002) analyzed existing taxonomies dealing with diagrammatic representations, and summarized the research interests of representatives of different disciplines. This kind of analysis, i.e. how the classifications are formulated in terms of dimensions of the problem being considered, has proven to be a very valuable source of information. It indicates issues which were perceived as significant within the field or discipline in relation to diagrams, recognizing the relative importance given to specific aspects, and revealing how authors perceived the role of diagrammatic representations as part of their research toolkit. For instance, an applied psychological approach would be concerned with either the effects that a diagram can have on problem-solving processes or with the identification of cognitive tasks that are part of creating or reading diagrams. Another example comes from linguistics. The diagram taxonomy rooted in this discipline could be biased towards analysis of linguistic trichotomy (semantics, syntax, and pragmatics of diagrams). Other disciplines and fields presented include visual programming, decision support, history and philosophy of science, architecture and cartography. The last three fields of studies enlisted by Blackwell and Engelhardt are education, data visualization and graphic design.

Researchers from the field of visual communication design attempting to construct a taxonomy might try to answer questions about systematization of examples of graphic work, proper management of which can increase the generative potential of a designer. Classification of visual vocabulary, the basic elements of visual language, could also be a subject of concern. Another issue could be the identification of contextual factors beyond the constraints of media or the preferences of the audience.

Blackwell and Engelhardt described data visualization researchers as being occupied with the characterization of data types, which could be matched with design variables of different representation structures looking for possible automation of processes of data presentation. The researchers involved would attempt to answer questions about the kinds of structures that would be the most appropriate for certain types of data. What kind of correspondence between representation and its referent should be chosen? What elements of the interface are necessary to provide the appropriate level of interaction? Is that what you mean? Most importantly, they were interested "to know how the choice of an appropriate visualization depends on the user's information-seeking goals." (Blackwell & Engelhardt, 2002, p. 57).

The researchers dealing with educational issues would be concerned with the need to prepare visually literate users of graphically presented information. The fundamental issue would be a notion of visual literacy itself as a distinguished set

of qualities. How can it be measured, assessed, taught? Another objective would be to identify potential strengths of diagrammatic representation as teaching and learning aids in the broader context of other educational purposes (Blackwell & Engelhardt, 2002, p.57).

The approach presented here would also display a consciously "biased" view into diagrammatic representations from the standpoint of the visual communication design field. Visual communication design is, from its very roots, a interdisciplinary endeavor. It operates on the border between disciplines and is aimed at facilitating communication between an originator of a given message and its intended recipient. The work of the designer often demands collaboration with professionals from other fields or responding to the needs of clients coming from a variety of backgrounds and practices. The main goal of this research stemmed from the recognition of the importance of building a common language between practitioners of various disciplines and designers – common denominator enabling, whenever possible, precise articulation of issues crucial to designing diagrammatic communication. A very good example of a practical application of such an approach could be the research into design briefs, which are a kind of written agreement between a designer and a client regarding the nature of the work to be done.

The approach used here sought also to establish a shared ground for studying examples of diagrams from different domains but in terms, which, if possible, would avoid jargon and would not require specialized knowledge of the specific disciplines. Instead it would make the designer conscious of different factors of context that must be considered in the project. To be able to react flexibly and efficiently to new tasks and communicate easily with people across disciplines, the designer must develop a visual literacy grounded in a rich set of meaningful examples ordered according to a coherent framework. It could act as a frame of reference useful in approaching diagrams from a design perspective. Consequently, a deepened study of already devised design solutions placed in a broad contextual description would enable designers to gain a better overview of the possibilities of diagrammatic language and increase their generative abilities in the creation of new designs for specific purposes.

The rationale for the construction of a framework can be condensed according to the following three-fold division showing benefits for three groups of potential users. For designers, the framework could be a tool with strong practice-oriented implications. Design researchers could use it to study specific aspects of diagrams. Finally, design students, whether oriented to practice or research, would be able to structure their efforts and direct their thinking in undertaken projects regarding diagrammatic representations.

Design practice

- providing a common platform and language to discuss possible solutions between designer, originator and intended recipient of the message;
- organizing and supporting the study of a designer's own collection of visual material connected with a project; and
- serving as a thinking tool for generating new ideas.

Design research

- enabling broad, cross-disciplinary comparisons and generalizations based on study of gathered examples;
- enabling a broad overview to detect patterns across fields;
- providing organizational principles for gathering examples; and
- supporting the creation of problem specific frameworks.

Design education

- training design practitioners and researchers.

This division was introduced here for clarity rather than to indicate boundaries in the research presented. Design research is part of design practice, and learning and teaching also have strong practical and research implications.

2. DEVELOPING AN OPEN FRAMEWORK FOR STUDYING DIAGRAMS

2.1 Background

The idea of the framework was conceived while studying Michael Twyman's work, in particularly his "Schema for the Study of Graphic Language" published in 1979. It is important to understand Twyman's goals behind the schema. He stressed that the schema was more about directing thinking by providing a device for reflection rather than defining graphic language. It was meant to "stimulate thought and discussion" (Twyman, 1979, p. 118). He developed his approach as a response to, in his opinion, two main practical questions arising while designing any kind of graphic communication:

- Which mode of symbolization should be used to present the intended information?; and
- Which methods of configuration should be used to organize visual elements of the message?

These two main categories formed two axes organizing the matrix to encompass different examples of graphic language (*see Figure 1*). The chosen categories were intended to enable easy application of the schema in real-life design settings.

One goal of the Twyman's approach was to expose the unifying property of such a schema attempting to embrace very different instances of graphic language. It revealed the underlying commonalities of different approaches and articulated important distinctions. Patterns created by the schema could reveal gaps in theory, enabling more precise questions about the characteristics of graphic language. Also "negative spaces"[2], which refer to cells without a provided example (the 24th cell should hold a schematic list) in the schema matrix points to unexplored possibilities, or where examples to support graphic language practice and theory could not be found. The author was also concerned with the difficulty to draw the precise distinctions between categories in such a broad study of graphic language. The boundaries of the cells, as noted by the author, could be the subject of further changes and more accurate subdivisions. The level of possible accuracy of the matrix is open and could be adjusted to the needs that

2. This term was used by Ruecker and Liepert (2006) in their discussion on Mendeleyev table of elements. The detailed description of their findings is presented in the following part of this document.

Method of configuration

Mode of symbolization	Pure linear	Linear interrupted	List	Linear branching	Matrix	Non-linear directed viewing	Non-linear most options open
Verbal/ numerical	1	2	3	4	5	6	7
Pictorial & verbal/ numerical	8	9	10	11	12	13	14
Pictorial	15	16	17	18	19	20	21
Schematic	22	23	24	25	26	27	28

Figure 1. Twyman's matrix. Illustration from the article (Twyman, 1979). The numbered cells have had visual examples assigned to each one in the accompanying article (see *Appendices*). The only cell without a visual equivalent is the 24th cell referring to a schematic list.

The operational capacity of the schema was secured by an emphasis on clarity and ease of understanding. The author was aware that additional dimensions could be incorporated to the matrix, for instance the one denoting a time factor. However, the focus on clarity, which made the framework a strong and frequently-used teaching aid, also prevented Twyman from extending it in this direction.[3]

Similar principles were identified in the well-known Mendeleyev periodic table of elements by Ruecker and Liepert (2006). They provided a thoughtful analysis taking advantage of information about process and circumstances of its development available in literature. They attempted to discuss methods used by Mendeleyev to determine patterns in data concerning the elements.

The first principle involved "using multiple matrices for pattern finding." Unlike the previous attempts to provide with a conceptual structure to the growing body of knowledge about the elements, Mendeleyev had used a method of rearranging index cards until a comprehensive pattern emerged. This principle was later referred to by Bertin (2001) as re-arrangeable matrices for pattern identification.

Another principle related to compressing rich information into a space-efficient form. The compressed and inclusive character of the chosen format and

3. The simplicity of the approach in connection with the educational purpose, was emphasized by Michael Twyman in personal conversation at the Department of Typography and Graphic Communication in Reading on May 15, 2007.

strategies for displaying rich data included:

- provision of color-coding;
- abbreviations; and
- tabular way of localizing representations of elements, which stemmed from index card system of pattern finding.

The authors also identified three out of the seven graphic variables outlined in the Bertin's taxonomy consisting of color, shape, scale, tonal value, texture, orientation, and location (as cited by Ruecker and Liepert, 2006):

- scale (differentiating the symbol of the element from its atomic weight and number);
- color (to identify element groups); and
- location (resulted from the atomic number).

A third principle involved in the creation of the periodic table related to the provision of a legend explaining rules of notation system developed for coding information. The aforementioned compressed and inclusive approach would not be possible without a consistent system for codifying information and an efficient way for explaining it.

The fourth principle dealt with the potential generative possibilities of negative spaces. Empty spaces can indicate that a data set is incomplete or incorrect. They point to areas where further exploration would be worthwhile and might suggest where the method could be extended filling the gaps in knowledge.

The strengths of Twyman's schema and the principles of the Mendeleyev model were helpful in setting up a list of intended properties of the framework, which is a core issue of this research.

Further reading on issues of classifying graphic language has uncovered a multiplicity of perspectives emphasizing distinctive aspects of diagrammatic representations that are equally valid and plausible. The informative collection of such approaches was put together in a tabular form by Blackwell and Engelhardt (2002) (*see Figure 2*). The authors were able to identify nine aspects repeated across taxonomies thus creating a kind of metataxonomy. The metataxonomy listed three groups of aspects referring to signs and graphic structure, meaning, and context. The first two are related to representation and the third one is related to context:

- signs or components of a diagram (basic graphic vocabulary, types of tokens, continuum of pictorial abstraction) and graphic structure of a diagram (graphic structure);
- meaning of a diagram (mode of correspondence, the represented information); and
- context-related aspects (task and interaction, cognitive processes, social context).

These distinctions were identified through the analysis of more than fifty taxonomies to study diagrams.

RESEARCHER	EXAMINED ASPECT								
	Diagram				Meaning		Context		
	Vocab	Tok	Abstr	Struc	Corr	Inform	Ta&In	Cogni	Social
1897 Peirce					5				
1921 Kandinsky	1								
1923 Karsten						6			
1963 Werner & Kaplan		2			5				
1964 Harnson				4					
1965 Barthes					5				
1965 Krampen		2							
1966 Knowlton				4	5				
1967 Bertin	1			4		6			
1968 Bowman	1		3			6			
1969 Arnheim			3		5				
1969 Dale								8	
1976 Stewart	1			4					
1977 Macdonald-Ross						6			
1978 Barnard & Marcel		2							
1979 Garland						6			
1979 Twyman		2		4					
1980 Doblin		2				6			9
1981 Hardin				4		6			
1984 Richards			3	4	5				
1985 Martin & McClure							7		
1985 Sampson		2			5				
1986 Mackinlay				4		6			
1986 Owen					5	6			
1986 Wood & Fels									9
1987 Larkin & Simon					5			8	
1987 Saint-Martin	1								
1989 Winn		2		4			7	8	
1989 Wurman						6			
1990 Rankin				4		6			
1990 Roth & Mattis						6			
1990 Wehrend & Lewis						6			
1991 Nyerges						6			
1991 Wexelblat						6			
1992 Bennett & Flach						6		8	
1993 Price et al							7		
1993 van der Waarde		2							
1994 Roth et al	1			4					
1995 Bullimore et al								8	
1995 Cox & Brna								8	
1995 MacEachren						6			
1995 Newsham	1								
1996 Cheng						6			
1996 Chuah & Roth							7		
1996 Engelhardt				4					
1996 Green & Petre							7		
1996 Ittelson	1	2							9
1996 Kress & van Leeuwen									9
1996 Scaife & Rogers								8	
1997 Blackwell								8	
1997 Strothotte		2							
1997 Tversky					5	6			9
1997 Tweedie							7		
1997 Zhang								8	
1998 Green & Blackwell							7		
1998 Marriott & Meyer							7		
1999 Card et al	1			4		6	7	8	
1999 Elkins				4	5				
1999 Horn		2		4					
	Vocab	Tok	Abstr	Struc	Corr	Inform	Ta&In	Cogni	Social

Figure 2. Chronological check-list of diagram taxonomies by different authors addressing nine aspects of diagrammatic representation grouped in three sections: the diagram, the meaning – these two representation related, and the context (Blackwell and Engelhardt, 2002). For instance, Twyman's schema from 1979 is classified as pointing to types of tokens (called modes of symbolization by Twyman) and graphic structure (Twyman's method of configuration) (the list was composed by Blackwell and Engelhardt, 2002).

Based on what was learned from the literature on diagrams and frameworks, the planned framework was outlined conceptually. A research question was formulated to structure the research process, which included:

1) Understanding the context of the field of diagram study;

2) Conducting background research in literature to get to know already developed approaches to the issue;
3) Conducting semi-structured interviews to deepen understanding of discipline specific approaches and points of view;
4) Conceptualizing the original approach
5) Building the framework; and
6) Proposing possible use cases and embodiments of the framework; and
7) If time allows conducting studies of the framework implementation.

Further reading on diagrammatic representations resulted in the following discussion on diagram definitions, presentation of other frameworks, and set the ground for conducting interviews with experts from a variety of disciplines. Following this, an attempt will be made to show why diagrams are important and why it is worthwhile to study them.

2.2 Research question

The research question presented here was formulated at the beginning of the research. It was a response to the two-fold issue of building a coherent framework and its suitability for a design educational environment. However during the course of the research it became clear that the outcomes could be also significant for design practitioners, and researchers. The possible scope was extended, also due to the above discussion of principles guiding creation if other frameworks, to include creating, using, and studying diagrammatic representations.

To direct the research process, the following research question was formulated:

> *How can an open framework for the creation, use, and study of diagrammatic representations be developed as a resource for visual communication design students, practitioners, and researchers?*

To better guide the research process, the question was broken down into separate components and steps:

> *development of an open framework*
>
> There are several steps designed to provide designers with a concise, accurate, and open framework that could be used in educational setting as a tool supporting practical work on projects as well as theoretical investigations into the realm of graphic language:

1) Understanding the context;
2) Conducting background research;
3) Conducting semi-structured interviews;
4) Building the framework; and
5) Proposing possible use cases and embodiments of the framework.

study of diagrammatic representations

The utilization of the framework should allow for:
1) Describing given example of diagrammatic represetations
2) Differentiating between examples;
3) Developing new diagrammatic representation; and
4) Building an understanding of how diagrammatic representation could work.

resource for visual communication design students, practitioners, and researchers

The operational framework for the study of diagrammatic representations should be provided.

2.3 What is a framework?

The notion of a "framework" is understood here as a fundamental structural order of central ideas building a specific concept. A "conceptual framework" as noted by Waller (1987) may be used quite loosely to denote a schema for thinking about certain phenomena in (more or less) structured manner. It is a foundation, which establishes a set of terms for approaching and understanding specific concepts.

The framework developed here could be understood as a set of interconnected concepts, which would create together a comprehensive tool for describing, differentiating and understanding, developing diagrammatic representations of various kinds. The characteristic of the framework would follow principles already identified in the literature noted above to:

- be a device for reflection (directing thinking);
- reflect authentic demands within the field;
- be operational;
- provide with unifying and differentiating capacity regarding the subject;
- be condensed and inclusive; and
- offer generative possibilities.

The notion of this kind of a tool requires the following operational capacities.

- It was based as much on a theoretical approach as on real-life experiences.

4. Waller pointed to examples of possible formats. There are more formal structures as taxonomies (which order data according to the most relevant dimensions), identified set of principles (rules) directing the crucial elements in the field of study, theoretical models, which embody a coherent theory able to explain something in satisfactory manner. Less formal structures would be metaphors, analogies or even slogans and catchphrases (e.g. "a picture is worth a thousand words") able to organize and direct our thinking about a problem at hand (Waller 1987).

To ensure this "on the ground" perspective, the utilization of qualitative methods for design research was planned: interviews and mini group discussions (not conducted due to time constraints). This process was envisaged as an open-ended exploration engaging experienced representatives from domains other than design as well as design experts, practitioners, and students.

- Although interdisciplinary, the framework should be rooted in the theory of the field of visual communication design to avoid arbitrariness of the schema and address the needs of the particular group of users visual communication designers. The schema should be readily and easily accessible and applicable for designers at different levels of proficiency (the knowledge required to use it does not have to be extensive).
- It was important that the framework should remain "open" for extensions required by a particular context of use. Although the general structure was intended to serve in most of the imaginable situations the "granularity" (the level of detail) of individual aspects or factors within the schema could be adjusted in order to suit most exactly and accurately a particular situation. It should be noted that the distinctions provided within the framework should be detectable by designers in provided examples. The divisions within the framework should also be significant from the point of designers and be relevant to the main aim, which is an exploratory and explanatory attitude towards diagrams.[5]

2.4 Diagrammatic representations

2.4.1 Definitions

Richards (2002, p. 86) provided an etymological knowledge about Greek roots of the word "diagram", noting that:

> "[d]ia is a prefix meaning 'through, through-out (of place and time); through the agency of' and gram is a suffix meaning 'something written, a letter'. Dia in this context presumably means one thing standing for another (through the agency of), and the suffix gram implies marks on the surface."

Richards (2000) himself defined a diagram as a graphic display – a special case of pictures in the broader category of images – used for picturing relationships. If these relationships are spatial a diagram can represent them in more or less direct manner. When the relationships are non-spatial, the diagram performs as a kind of metaphoric picture (p. 93).

Kulpa (2004) wrote in the same vein, defining a diagram as a two--dimensional structure, in which spatial and graphic relations between elements are interpreted as relations in a represented structure.

5. The last three listed operational features were based on general constraints of classification, as identified by Goel (1995, p. 137-139).

The above definitions seemed to give priority to features of the diagrammatic representation itself. The significant modification might be found in other group of definitions, which have acknowledged to bigger extent the agency of the user/perceiver by introducing the notion of interpretation or reading and the intended use.

Important aspects of the perceiver's interpretation were highlighted by a study on visual representation classification conducted by Lohse et al. (1994). This experiment was meant to indentify "how people classify visual representations into meaningful, hierarchically structured categories." (p. 37) and in fact, the results "have focused primarily on perceived similarity" (p. 49). The authors were successful in finding eleven categories of visual representation, which came from classification tasks done by participants, and being able to characterize each of them according to what people had said. The way participants named, sorted, and rated representations were based on the visual resemblance to representations that they might have used, seen, or created, etc.. They exhibit only their general attitudes, and are not rooted in careful interpretation of given examples.

The definition of a diagram arising from this study, interestingly, was divided in two distinct groups: structure diagrams and process diagrams. According to Lohse et al. (1994), the structure diagram is

> "a static description of a physical object. The spatial data expresses the true coordinate dimensions of the object (...) Process diagrams describe the interrelationships and processes associated with physical objects. The spatial data expresses dynamic, continuous, or temporal relationships among the objects in process diagrams." (p. 44-45)

Asking people how they categorize visual representations could be another approach useful in finding sources of possible diagram definitions.

McCarty (2004) discussed the diagram issue from a similar perspective, pointing out that within a group of representations that are usually called diagrams, there are many separate, uncorrelated diagrammatic systems. These systems have their own rules of reading as different as precisely measured schematic drawings and handmade sketches denoting symbolic relations between objects. What is really important in identifying a representation as a diagram is the convention used to read it. The way of reading allows us to overlook some discrepancies and points to significant information driven by an intentionally chosen purpose (p. 258). This insight suggested the significance of the perceiver's interpretation and understanding for the planned framework.

James Clark Maxwell (cited by Richards, 2002, p. 86) has verbalized it slightly differently, stating that a diagram is:

> "(...) a figure drawn in such a manner that the geometrical relations between the parts of figure illustrate relations between other objects. They may be classed according to the manner in which

> they are intended to be used, and also according to the kind of analogy which we recognize between the diagram and the thing represented."

This could refer to another view on diagrams noted by Nowviskie (2004), who recognized possibilities of diagram use as a generative and exploratory tool. She was mainly interested in potential available in diagrammatic communication as a tool applied in interpretative tasks in literary studies on digital texts within a computer environment. This extends the former views, where diagrams were understood mostly as explanatory devices (illustrating, articulating, or explaining the features of represented object), to emphasize their generative potential.

This notion is currently at the core of the multi-modal reasoning studies (involving philosophers, psychologists, logicians, mathematicians, and computer scientists), where non-symbolic and especially diagrammatic systems could carry certain types of reasoning. This approach has been developed in logic and mathematic proofs made exclusively in visual formal languages. However, as Nowviskie (2004) noted, from the humanities point of view, it is valuable that "[s]ome recent work, for instance, makes an argument for the deliberate retention of 'vagueness' in diagramming, demonstrating that this quality can be exploited for effective problem-solving." (p. 125).

Nowviskie presented a definition by Chandrasekaran, working in the field of cognitive psychology, that a diagram is a "form of spatial representation, explicitly constructed and intended to be visually processed, containing elements that have a conventional semantics, displaying the spatial relations among the elements" (cited in Nowviskie, 2004, p. 116). This definition extended Richards' focus on including direct references to spatiality and visual character. More importantly it called attention to the intentionality of its design and conventions that may guide understanding of the presented relations, by providing cues about "which aspects of the diagram are to be taken seriously and which are to be taken as incidental" (cited in Nowviskie, 2004, p. 116).

Iwasaki (cited by Nowviskie, 2004) provided another definition from the same domain of multi-modal thinking studies, which has more a general meaning, stressing the aspect of the originator of the diagram and his goals or tasks that are intended to be realized through the diagram. He suggested that:

> "Diagrams are abstractions, meaning that they extract and summarize a selective subset of information and represent (along with their 'content') the rhetorical and interpretative decisions of their creators." (Iwasaki, cited by Nowviskie, 2004, p. 116)

Thus the most important functions from this point of view would be:

- "helping extend short term memory";
- "helping organize problem solving by spatial organization of related information";

- "helping organize problem solving (...) as sentences in a 2-D language with specialized rules of inference";
- "providing a model of the premises so that plausible subtasks may be hypothesized for formal interference"; and
- "providing a model of the premises from which consequents can be inferred and asserted." (Chandrasekaran, 2006, p. 204-205)

This third group of definitions, or approaches focusing on functionalities, is well exemplified also in the design field by Frascara (2001). He supplemented the initial set of diagram functions, borrowed from Bertin – to record, to support understanding, and to communicate – (in Frascara, 2001, p. 165) with crucial functionality, which supports thinking in terms of ecologies of information. It was understood in less formal terms than in approaches from the multi-modal reasoning field of studies, referred to above. The advantages of diagramming would be, therefore, in its capability of "presenting hierarchies, inclusions, simultaneity, distinctions of levels, multiplicity of kinds, and complexity of connections." (Frascara, 2001, p. 16) He noted that:

> "It is the ability to discover patterns, hierarchies and causalities (...). Because diagrams can synthesize different factors or dimensions of a situation, they lend themselves to exploration of complex interrelationships that would otherwise escape attention." (Frascara, 2001, p. 169)

From a design perspective, diagrams and diagramming could be thought of as "a way of thinking" (Frascara, 2001, p. 165). For Frascara, diagrams are especially suitable for denoting certain kind of problems, namely complex, ill-structured ones, where presumably any intervention may cause many unpredictable outcomes if one would try to simplify or reduce the amount of data to be taken into account. Additionally, he suggested that little has been done to date to study systematically the phenomena of diagrams as thinking devices.

The fourth approach, probably the most radical, is a resignation from the explicit definition. Collecting examples of frameworks and looking at the dimensions of created conceptual spaces was an approach suggested by Blackwell & Engelhardt (2002). They advocated this kind of approach, i.e. getting the broader view of interests populating the field, pointing out that it is not so much biased by a priori settled definitions. For instance, for the authors' clear-cut definition of a diagram would be impossible without limiting the scope of the subject matter and excluding interesting instances of diagrammatic representations.

Another interesting insight regarding diagrammatic representations coming from Blackwell & Engelhardt (2002, p. 48) is that:

> "[a]ny visual representation that is not purely textual or purely pictorial can usefully be analyzed to discover its diagrammatic content, whether or not it should formally be defined as a »diagram«".

Richards (2002) expressed a similar opinion, suggesting that it is perhaps more appropriate to think about diagrammatic tendencies in graphic representations rather than diagrams as clearly defined kinds of graphic representation. These statements have undermined divisions in the types of graphic representations based on analyses excluding contextual factors relevant to the circumstances accompanying perception. They support the claim that interpretation of visual representation is always a relative construct, and is not an absolute characteristic that might be steadily attached to any visual representation. Twyman's (1985) discussion about pictorial language also underscored the fact that determining whether an image is pictorial or schematic sometimes could be problematic. The circumstances of utilization, situational factors, can have decisive influence on the final interpretation.

Many different approaches have attempted to pin down conceptual distinctions regarding the notion of diagrams and other graphical representations. There could be observed a great array of approaches to deal with diagrams on a theoretical basis, which found their embodiment in a number of distinct definitions and taxonomies created from sometimes very distinct, discipline-constrained, points of view. To summarize, there are four main sources of possible differentiation of diagrammatic from non-diagrammatic representations:

- features of the representation itself;
- user/perceiver impact;
- representation utilization or task to be accomplished; and
- contextual factors.

Compared to what was identified as main aspects by Blackwell and Engelhardt (2002) in their metataxonomy (three groups of aspects referring to: signs and graphic structure, meaning, and context), there could be noted a significance given to contextual aspects of the user and the task at the expense of representation-related aspects.

The brief overview of several definitions of a diagram has provided the following list, significant for the approach developed in this document:

- it formed a base that initiated the construction of an original aproach to the issue;
- it provided a foundation for a better understanding of example frameworks discussed below;
- it provided a basis for interviews with researchers from different disciplines to get the image of their attitude towards diagrams use in their own areas of expertise; and
- it situated the research in a real world context, making it sensitive to various problems in the field of diagram studies.

2.4.2 Examples of other frameworks

Richards' schema

Richards' (2000) introduced a set of terms for discussing diagrams and a taxonomic model explaining relationships between features of diagrammatical representations.

To distinguish diagrams from other kinds of images, he pointed to the main function of diagrammatic display – to depict relationships. His definition, already presented in this document, detailed that if these relationships are spatial, a diagram can represent them in more or less direct manner. When the relationships are non-spatial, the diagram performs as a kind of metaphoric picture (p. 93).

For the purpose of analysis, Richards distinguished the "content model", which is a situation depicted on the display, from "content proper", standing for the meaning attached to the representation. The content model consists of various "significant elements", the smallest signifying elements in the display. The organization of significant elements in the content model governs the relational meaning of the diagram.

The first dimension of the framework, "mode of correspondence", covers the way meaning is conveyed in the content model in relation to content proper. If the relation depicted has a spatial character and it is presented through its spatial features of the diagrammatic representation, the signification is more-or-less direct. This is called literal correspondence. If the relationship depicted has non-spatial character the representation would be metaphorical (called non-literal correspondence). The degree of correspondence is shown on a continuum from literal through semi-literal to non-literal.

Another continuum useful for describing diagrammatic representation ranges from figurative to non-figurative and refers to pictorial qualities of significant elements (or level of pictorial abstraction). This feature is called "mode of depiction".

The third variable allows for an analysis of diagrams in their "mode of organization" aspect. It reflects an arrangement of elements within the content model. There are three main modes: grouping, linking and variation. The three modes form together a three dimensional taxonomic model in which different configurations of modes are possible (*see Figure 3*).

Richards (2002) also offered some important insights about the general nature of diagrams. Firstly, it is more appropriate to think about diagrammatic tendencies in graphic representations rather than diagrams as clearly defined kinds of graphic representation. Diagramming is a process of producing images with the particular function of picturing relationships. Formal qualities (schematization, using particular graphic elements etc.) cannot be considered as

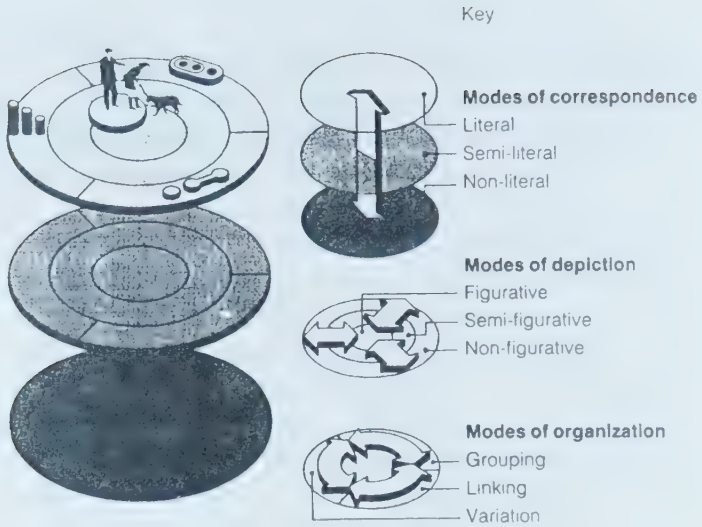


Figure 3. The schema as visualized by Richards (2002).

essential differentiating categories. Secondly, a diagram gains its significance only when users are able to relate its spatial relations to relationships represented.

Model of typographic contribution to language

Waller (1987) proposed a framework discussing typographic communication based on analysis of writer-text-reader relationships. The author recognized these relationships as possible sources of a visual structure of a given document. As noted by Delin et al. (2002/2003), this approach was unique in its capacity to describe a document as interrelations of language, communicated information, and its visual aspect. The framework identifies the following three structures, which serve particular purposes within the model of writer-text-reader relationship:

- topic structure presents information about argument of an author;
- artefact structure addresses constraints and opportunities, which stem from the physical character of the document; and
- access structure allows the reader to use the document, making an interaction possible.

These three structures can be realized or significantly supported by typographic features of the document. The structures inform and are integrated in an overall structure called conventional or genre structure.

Using the framework, it is possible to analyze documents from the perspective of the three-fold structure model of the genre – a "genre of typographically-organized documents" (Waller, 1987, p. 180). The model illustrates how graphic (typographic) features actively contribute to building cohesive documents along with the verbal components or images used.

Document genre model

Delin, Bateman, and Allen (2002/2003) presented a framework for describing genres of documents based on the framework provided by Waller (1987). They extended the number of levels of analysis to five: content structure, rhetorical structure, layout structure, navigation structure and linguistic structure. Additionally they proposed three "sources of constraints" – canvas, production, and consumption constraints – which influence all the structures mentioned earlier. Description according to five levels conforming to the constraints would enable to produce complex specifications of example documents.

This framework demonstrates a much broader space of interrelations of components that constitute a document than in Waller's case. It extends Waller's framework by including analysis of verbal as well as pictorial elements within the document. The structures do not refer only to typographical features.

Description at the content structure level is meant to provide characteristics of information, which are communicated in a document (in textual and pictorial form). That encompasses facts covered, their logical order, and hierarchies of information. The way the content is presented is shown in a description of the rhetorical structure level. It shows how particular segments of information are interrelated in order to provide a coherent overall argument. Both textual and graphic elements are taken into consideration at this level of analysis. The layout structure offers terms to analyze the arrangement of elements on the page or display and their graphical and typographical properties. The way the document should be traversed is signaled by graphic or textual cues. The description of the navigation structure identifies these cues and gives a description of their properties. Language used is the last category of description. The five levels are supplemented by constraints, which can influence the decisions made by an originator of the document in terms of canvas, production, and consumption. These labels refer to the fact that document must comply with specific requirements of the medium being used, methods of making and the intended use.

Together all the categories form a multidimensional space embracing a variety of document genres. Examples incorporated in this conceptual space will map relationships between levels of description (patterns which would indicate and define different genres).

Bernhardt (1985) comparison of different document genres

In his article "Text Structure and Graphic Design: the Visible Design", Bernhardt (1985) provided an approach to understand the connection between a type of written text and its graphic organization. He looked for patterns of rhetorical strategies embedded in the visual appearance of texts (*see Figure 4*). He proposed a continuum of visual organization starting from visually informative

to non-visually informative texts or, in other words, he divided text types according to the level of relative importance of their graphic component. He suggested that:

> "When a writer elects to make a text visually informative, the decision has consequences which extend down through the text to all levels of structuring, from the large rhetorical divisions of the text, to the intersentential strategies of cohesion, to the syntax of individual clauses."
> (Bernhardt, 1985, p. 19)

It is based on observations of how textual components and graphic components interweave to create a cohesive rhetorical structure to communicate in a specific situational context (the author compared four documents about the same subject matter prepared for different circumstances of use).

As an outcome, Bernhardt listed "levels of rhetorical control" and found out how they could be supported by the visual organization of written text. The same

Visually Informative	Rhetorical Control	Non-Visually Informative
-varied surface offers aesthetic possibilities; can attract or repel reader through the shape of the text; laws of equilibrium, good continuation, good figure, closure, similarity.	Visual Gestalt	-homogenous surface offers little possibility of conveying information; dense, indistinguished block of print; every text presents the same face; formidable appearance assumes willing reader.
-localized: each section is its own locale with its own pattern of development; arrests reader's attention.	Development	-progressive: each section leads smoothly to the next; projects reader forward through discourse-level previewing and backwards through reviewing.
-iconic: spacing, headings reveal explicit, highly visible divisions; reader can jump around, process the text in a non-linear fashion, access information easily, read selectively.	Partitioning	-integrated: indentations give some indication of boundaries, but sections frequently contain several paragraphs and sometimes divisions occur within paragraphs; reader must read or scan linearly to find divisions.
-emphasis controlled by visual stress of layout, type size, spacing, headings.	Emphasis	-emphasis controlled semantically through intensifiers, conjunctive ties; some emphasis achieved by placement of information in initial or final slots in sentences and paragraphs.
-subordinate relations signalled through type size, headings, indenting.	Subordinate Relations	-controlled semantically within linear sequence of paragraphs and sentences.
-signalled through listing structures, expanded sentences, parallel structures, enumerated or iconically signalled by spacing, bullets, or other graphic devices.	Coordinate Relations	-controlled semantically through juxtaposition, parallel structures, and cohesive ties, especially additive ties.
-linkage controlled visually; little or no use of semantic ties between sentences and sections; reliance on enumerative sequences or topicalization of a series.	Linking/ Transitional/ Intersentential Relations	-liberal use of cohesive ties, especially conjunctives and deictics; frequent inter-paragraph ties or transitional phrases.
-variety in mood and syntactic patterning; much use of Q/A sequences, imperatives; fragments and minor forms; phrases used in isolation.	Sentence Patterns	-complete sentences with little variation in mood; sentences typically declarative with full syntax.

Figure 4. List of rhetorical strategies (Bernhardt, 1985).

list of levels of rhetorical control is examined in the case of a document, whose integrity is based on non-visual strategies but lead to similar rhetorical results. Furthermore, this comparison enables the differentiate of more or less visually informative documents among given examples according to given categories of analysis (rhetorical strategies).

Affordance strength model (Ruecker 2007)

Ruecker's (2004) affordance strength model was conceived as an analytic tool, whose purpose is to aid in the study of new interfaces through benefits a user can gain from them. Gibson's notion of "affordance" was used as a core concept. Affordance defined by Gibson as "an opportunity for action" in this context was understood as potential activities previously not available for the user but enabled by the new interface (Gibson, cited in Ruecker, 2004).

The question asked by the author was how to study new interfaces and determine the distinctive affordances they can support at the early stages of design process. The model provides a set of related general concepts, which cover the most important aspects that would define the affordance strength of a given interface for intended circumstances of use. This approach allows for the study new interfaces even before a prototype is prepared and points to areas that may otherwise escape attention of developers.

The aspects were grouped according to three groups referring to:

- the planned object (the interface as a whole or just separate element);
- the user or perceiver of the object; and
- the contextual factors.

The following concepts interrelate to form a model of the affordance strength:

- *Tacit capacity* refers to the object and its suitability to the kind of situation under consideration. This capacity affords a desired action in the generally set circumstances.
- *Situated potential* is the capacity of the object to be in the right place at the right time. It is a particular situation, which is examined, not just a general suitability as in the case of the tacit capacity factor.
- *Awareness* refers to the user. It point to the fact that even the best suited object available for a certain action if not perceived as such will not be used and its affordance strength (here might called 'relative affordance', not absolute) for this particular circumstances would be weak.
- *Motivation* is the willingness of the user to perform a certain action.
- *Ability* is the capacity of the user to carry the intended action.
- *Preference* can be a crucial factor for the decision made if there are several possibilities of executing a specific action available. Preference can stem from previous experience, aesthetic qualities of the object or influences

of environment or other people involved so the factor can be studied as comprising several sub-factors.

- *Contextual support* is the first concept referring to the context. Context is defined as a set of features of a situation, which are not directly involved in the interaction of an object and its user but have their own importance as environmental factors.
- *Agential support* accounts for the influence of others not directly involved in the situation, who have their own volition and follow their own goals, etc.

2.4.3 Concept space

Concept space provides a visual overview of concepts from presented frameworks. It was meant as a directing tool for thinking about commonalities and differences of the frameworks (*see Figure 5*).

Figure 5. Concept space is the chronological visualization of concepts derived from analyzed frameworks discussing graphic language.

Twyman, 1979	Richards, 1984	Waller, 1987	Blackwell & Engelhardt, 2002 meta-taxonomy		Delin et al., 2002/2003
			basic graphic vocabulary	signs or components of a diagram	
			types of tokens		linguistic structure
	mode of depiction		continuum of pictorial abstraction		
method of configuration	mode of organization		graphic structure		layout structure
mode of correspondence	mode of correspondence		mode of correspondence	meaning of a diagram	rhetorical structure
		topic structure			
			represented information		content structure
			task and interaction	context-related aspects	navigation structure
			cognitive processes		
		access structure			consumption constraints
			social context		
					production constraints
		artefact structure			
					canvas constraints

2.4.4 Interviews

Participants from different disciplinary backgrounds were interviewed using semi-structured questions and discipline specific diagrams as examples. The main idea behind this approach was to get a variety of opinions on the issue of diagrams, note terminology which is commonly used, and possibly collect instances of diagrammatic representations used within their disciplinary contexts.

This exploratory research was aimed at mapping an initial terrain for understanding the diagrammatic representations used by professionals in their work with extensive amounts of data. Studying the creation and effect of diagrams in many fields was intended to help in:

- distinguishing major features of diagrammatic representations used;
- defining the phenomenon of diagrams in a broad context; and
- overcoming a bias of the researcher's own discipline in looking at diagrams.

These interviews with researchers, practitioners and educators from a variety of fields including visual communication design, humanities computing, psychology, art history, English philology and education were important as a way to ensure that the framework could support and reflect a broad spectrum of approaches towards diagram creation and use in a real-life communicational context. They were not intended to provide generalized views of diagram creation and use in different disciplines.

All five interviews are reported here in a detailed way, as they had a direct influence on my further research.

Participant 1

The first interview was conducted with a researcher from a psychology discipline. The discussion concentrated on examples of diagrammatic representation used as a part of his research practice. During the interview, he reflected on the issue of how envisaged diagrams could contribute to more effective work in the area of his expertise. The main problems in the researcher's process of working with large amounts of data were usually encountered when there is a need for interpretation of patient profiles coming from psychological tests. Thus the main issue is to facilitate the interpretative process, especially comparative tasks, by providing the means for gaining a comprehensive overview of available data in a condensed form.

The participant outlined the main principles that should be followed by a diagrammatic system of notation to be used as a facilitator in understanding how to organize complex data gained from a set of psychological tests.

The characteristic of such a system of presentation should:

- be easy to learn and use;
- allow extension and adoption to other components of the profile according to the researcher's needs;
- enable interpretation, which would follow easy-to-learn rules;
- be credible and enable significant aspects to be quickly apparent;
- be condensed but inclusive;
- enable spotting cross-test associations;
- facilitate integration of data into meaningful hierarchies; and
- allow for emergent patterns to be easily identified.

Participant 2

The second participant is a practicing visual communication designer as well as a design instructor at a university level.

Visual communication design practitioners consciously use visual methods and techniques in communication based on growing interdisciplinary research. They themselves tend to use and teach students to utilize visual materials and means at all stages of the design process. It seemed especially important to ask the graphic designer to reflect on diagrams as communication devices as well as tools utilized in the designer's own working methods. The idea of the framework was introduced as possible element of graphic design process, and also as a resource used for education purposes. But the main theme of the interview was concerned with the examples of a diagrammatic approach to typography. This provided an opportunity to set the background for the a case study involving elements of text visualization reported in the remainder of this document. The purpose was to have an opinion on the issues of typography features used as meaningful elements in text visualization examples.

For the purpose of the interview, diagrammatic typography, was defined as a way of setting typographic elements so that a reader can recognize correspondence between spatial arrangement of these elements and represented relationships in a given set of information. The discussed topics embraced the following:

- potential of mapping the results of analysis directly onto the text through variations in its typographic features;
- research already completed on typographic structuring (also referred to as typographic cuing) providing with insights about mapping structural information about text and an author's argument onto its typographic form (writers of functional texts like manuals or textbooks usually take advantage of rich visual signaling to enable reader to get a facilitated access to the content of the text;

- a possibility to draw an analogy between the situation of the self-conscious reader of functional texts and the researcher working with text visualization;
- already devised descriptive schemes (e.g. the Twyman's framework) aimed in embracing variations of diagrammatic forms in printed and digital environment.

The participant was presented with a set of visualizations using diagrammatic typographic as a carrier of information. There are several comments about the set that are significant for this report:

- it has a capacity of questioning typographic traditional goals from a new angle;
- it plays with typographic conventions;
- it looks interesting, first view aesthetic qualities very important in approaching this kind of visual objects;
- it looks more like an "artistic" work that a "research" approach; and
- its rules of understanding are not self-explanatory.

It is not the same to visually present an argument referred by the text author (as in typographic cuing applications) as data from text analysis (as in text visualization). These kind of data are probably different so the means to display them are different. The similarities between the self-conscious reader and the researcher working with digital text probably could be traced at the very general level but closer look would certainly reveal significant differences.

The participant's reflection in regard to frameworks presented was that surely they could be beneficial as preliminary frameworks useful to provide with preliminary understanding of diagrammatic possibilities of typography but better results would be gained while just working with type, in the context of particular visualization projects.

Participant 3

This participant is a researcher and educator in the humanities computing field and was consulted to discuss the visualizations used by humanities scholars while analyzing literary text using a computer.

The following information resulted from interview in relation to humanities computing within the field of literary studies:

- There is a constantly growing amount of textual material available for literary researchers in forms of on-line digital archives, libraries, collections.
- There are specific techniques developed, which enable the researcher to extract specific information from a large volume of accessible textual material, find unpredictable relationships or deviations from usual patterns.
- All of this could lead to the creation, validation, or rejection of novel interpretations of literary texts.
- Text visualization – a graphic presentation of data – offers advantages,

which could contribute the abovementioned goals of the field, but is not sufficiently explored and developed in terms of the means of presenting often extensive results to the user.

As concluded by the participant, the framework for discussing diagrammatic representation could be a valuable resource for exploring aspects of text visualization with special attention given to the potentially large group of users in the literary scholars community, who require easy-to-use interfaces and comprehensible representations tailored to their research objectives as well as their abilities to cope with information presented in the new formats. Adequate visualizations of the results of analyses could be crucial in informing further phrases of literary research, formulation of new hypotheses and final interpretation insights through:

- enabling large amounts of texts available for rapid inspection and interpretation;
- allowing discovery of emergent, non-anticipated properties of textual data; and
- facilitating recognition of large-scale and small-scale features of texts and their interconnections.

Participant 4

The fourth participant is an art historian. As a point of departure for discussion was a question about diagrammatic strategies used in art practice by different artists as Maciunas (from the "Fluxus" movement), Marc Lombardi, or Arakawa just to name the few. In the course of interview, the discussion moved to a more general one about how our conceptualization of reality is influenced by visual literacy we develop, and to which extent superiority of language shapes our way of producing knowledge. For instance, if we say "visual language" how the notion of language bias our understanding of the visual. These problems are significant when considered in the context of taxonomies and frameworks discussed in this document. Most of them are verbally presented. Also the approach developed in this research tends to verbal conceptualization of visual material. The emphasis placed on this fact was the most important finding from the interview and prepared the background for the next discussion with a participant from the film studies area.

Participant 5

The fifth participant's field of expertise is in film studies. He has published extensively critical works about cinema in Canada and worldwide.

He was asked to comment on to what extent, if at all, a cinematic image – how it is conceived, produced and consumed – carries some features common to a broadly defined diagram.

Regarding the notion of a diagram and diagrammatic thinking, it was possible to distinguish several characteristic features that participant agreed upon to be representative for diagrams and which are also meaningful in the context of filmmaking (working metaphor: "film as a diagram").

Firstly, a common ground has to be established by noting that both are specific kinds/types of representation and require specific approach to read them out. Films are highly conventional. They follow a set of rules already established: story structure, types of characters etc. the example of highly structured format is a sitcom. One of the features mentioned was a reductive character of representation. Economy and effectiveness in communication requires that only constituent features of a situation are depicted.

Secondly, the notion of emergence was introduced. Connection of certain elements produces meaning, which is otherwise not present in the elements alone. Films have usually an analogical character of presentation of story (a time-based story is presented in a time-based medium; subsequent scenes depict subsequent events) although a famous quotation from Godard, recalled in the discussion, may contradict this claim: "A story should have a beginning, a middle, and an end... but not necessarily in that order".

Another aspect of films, which is shared with diagrams, is over-specificity – the representation compels specification of information. This aspect of diagrammatic representation in the hands of a skillful director can be a strong rhetorical tool. For instance, a carefully chosen mis-en-scene, can tell a lot more, or even can be used instead of spoken dialogues. The participant suggested that sets used in Antonioni's masterpieces could be chosen as a great example of such an approach.

Examples of diagrammatic thinking in the film-making process, which were identified as worth of closer exploration include:

- Alfred Hitchcock's approach to diagramming a precise storyboard;
- Antonioni's final scenes from "The Adventure" or "Passenger" as "crystallization of experience" summarizing the whole story;
- Robert Altman's way of story construction using separate threads and representations of scenes on cards; and
- Sergei Eisenstein's method of correlating all filmic elements (sound, image, dialogue, etc.) by sketching diagrams carefully calculated in regard to filmic space and time.

All five interviews reported above were, each in its own way, influential for the research presented here. However, they mostly posed more questions than

gave ready-to-use answers. What makes a visual representation diagrammatic? How can diagrammatic tendencies in visual representation be supported or assisted? By what? In which circumstances? Can one representation be diagrammatic in one context and non-diagrammatic in another?

2.5 Defining diagrammaticity

To explore these questions, it was useful to devise a working concept, which could direct the labeling the complexity of diagrammatic qualities of visual representations. This referred to interrelations between qualities of overall situation (introduced below as aspects and factors), leading to possibly exhaustive description of conditions that enable diagrammatic qualities of representation to emerge.

The proposed concept of diagrammaticity embraces aspects of the way visual representation works, determining its diagrammatic character, and situational factors, which condition the emergence of the aspects. Developing a concept of diagrammaticity was an attempt to provide with language, that could account for diagrammatic advantages of visual representations, and establish a common set of terms to compare how different representations utilize diagrammatical potential.

The concept presented here is based on the notion of diagrammaticity developed in the area of multimodal reasoning (Barkowsky at al., 1996). Basic distinctive criteria accounting for diagrammaticity have been formulated in the following ways:

- compositional (rhetorical) divisions, as hierarchies in represented information, are mirrored in the visual structure of representation; there is direct correspondence between representing and represented structures;
- location of each element and position in relation to other elements of representing structure are determined and always meaningful ("extractability" of relations);
- different conventions (interpretational frame is provided) are employed to narrow what can be inferred directly and what could not; and
- overview (simultaneity of display, context) is used to keep rhetorical structures clear (each element is still accessible).

This list consists of fundamental criteria, which have been identified for a specific purpose, i.e. for a model of a component of a diagrammatic reasoning system (Barkowsky et al., 1996, p. 1). Each example of diagrammatic representation should comply with all four rules. The criteria present a minimum set of conditions that enables us to differentiate diagrammatic representations from other forms of representation.

For the purposes of this research, the concept of diagrammaticity has a much broader meaning, and all enlisted criteria are part of the framework

presented below. Diagrammaticity is a possible state of affairs involving visual representation, and is specified in relation to the description of the situation in which visual representation is involved.

It is important to think of diagrams not as a distinct type of graphic representation, but as a feature referring to a more or less strong inclination of visual representations towards specific characteristics. The core of the concept is a set of aspects, present or potential, capable of being manifested in the appropriate conditions. Diagrammaticity is not an absolute characteristic of any representation. It is relative and stems from a variety of aspects of a considered situation. Diagrammacity goes beyond definite articulation of what a diagram is. Instead it emphasizes the circumstances that enable diagrammatic communication to take place.

Diagrammaticity, from this point of view, may be present at different degrees of intensity and is conditioned by the situation, in which visual representation is perceived. Diagrammaticity points to any visual representation as potentially capable to hold diagrammatic communication, encompassing latent or emerging diagrammatic properties of visual representation. The concept of diagrammaticity helps to answer the question about any given representation "how diagrammatic is it?" instead of "is it diagrammatic?" to paraphrase Westcott's words about iconicity (as cited by Waller, 1987, p. 107). The concept can be used in approaching a variety of visual representations and contexts.

All qualities (aspects and factors) correlate to form an open, interrelated set. This is the set of aspects and factors that can be extended according to encountered situations and growing experience in its use.

The framework was intended to provide a fundamental structural order of central ideas to build the concept of diagrammaticity. It was an attempt to anticipate broad range of possibilities in a flexible and open space of interrelation and mutually influencing components. The operational embodiment of the concept is in the proposed framework.

3. THE FRAMEWORK

The approach presented here attempted to map the field of diagrammaticity by looking for characteristics often associated with diagrams. This was done through:

1) Preliminary identification of terms that address significant features of diagrammatic representations was possible through searching through characteristics from relevant literature on diagrams.
2) The study of the taxonomies already devised for accounting of multitude of examples of diagrams was also a significant source of possible terminology.
3) The series of interviews conducted with experts, practitioners and educators from different fields including film studies, humanities computing, psychology, art history, and graphic design.

This preliminary choice of "language" for description was more or less intuitive, in a sense that the choice is made by cutting across different disciplines. Certain terms might slightly change their meaning in response to the context, and new associations could be derived from these juxtapositions. If this was the case, it was recorded during the course of the research.

The first step was to collect a set of aspects of visual representations that have been mentioned quite often in literature regarding description of diagrammatic representations. The chosen literature was taken from a broad array of fields of study to ensure multiple points of view. Due to time constraints, this is not an exhaustive set (for a quick overview, please see reference list).

The manifestation of different aspects accounting for diagrammaticity is specified in relation to the situational factors in which a particular visual representation is involved. So the aspects, which build the core of the framework, are capable of being manifested by visual representation only in appropriate situational conditions, which are described by the factors.

To provide a more reliable image of the sources of the aspects, a number of factors, mostly of non-visual (nongraphic) character, were supplemented to the framework. They need to be taken into consideration to build the proper image of situation, when a visual representation is utilized. To determine the

interconnections between aspects and factors, and the conditions influencing their emergence, a conceptual framework was created. The framework offers the means for describing aspects that influence the way visual representation may work and by adding situational factors that place aspects in a broad context, thus making them more easy applicable in practical settings. The granularity of factors, i.e. how detailed the description would be, is again an open question. The level of detail will be adjusted each time a specific research problem is posed and the framework used. The framework, which is created by mapping interconnections of aspects and factors, is based on an aspects/factors approach used by Twyman (1985).

3.1. Framework structure

The framework – based on the concept of diagrammaticity – is meant to provide a structured means to study how a diagrammatic representation works, in other words what are the sources of diagrammatic aspects of representation (*see Figure 6*).

The framework can demonstrate the usefulness of the concept of diagrammaticity in its ability to show the diversity and value of diagrammatic communication in the context of different disciplines and communication

Figure 6. An explanatory diagram of the general components of the concept of diagrammaticity. The main conditional factors of diagrammaticity are identified as belonging to four groups referring to: the visual representation, the user/perceiver, the task, and the context.

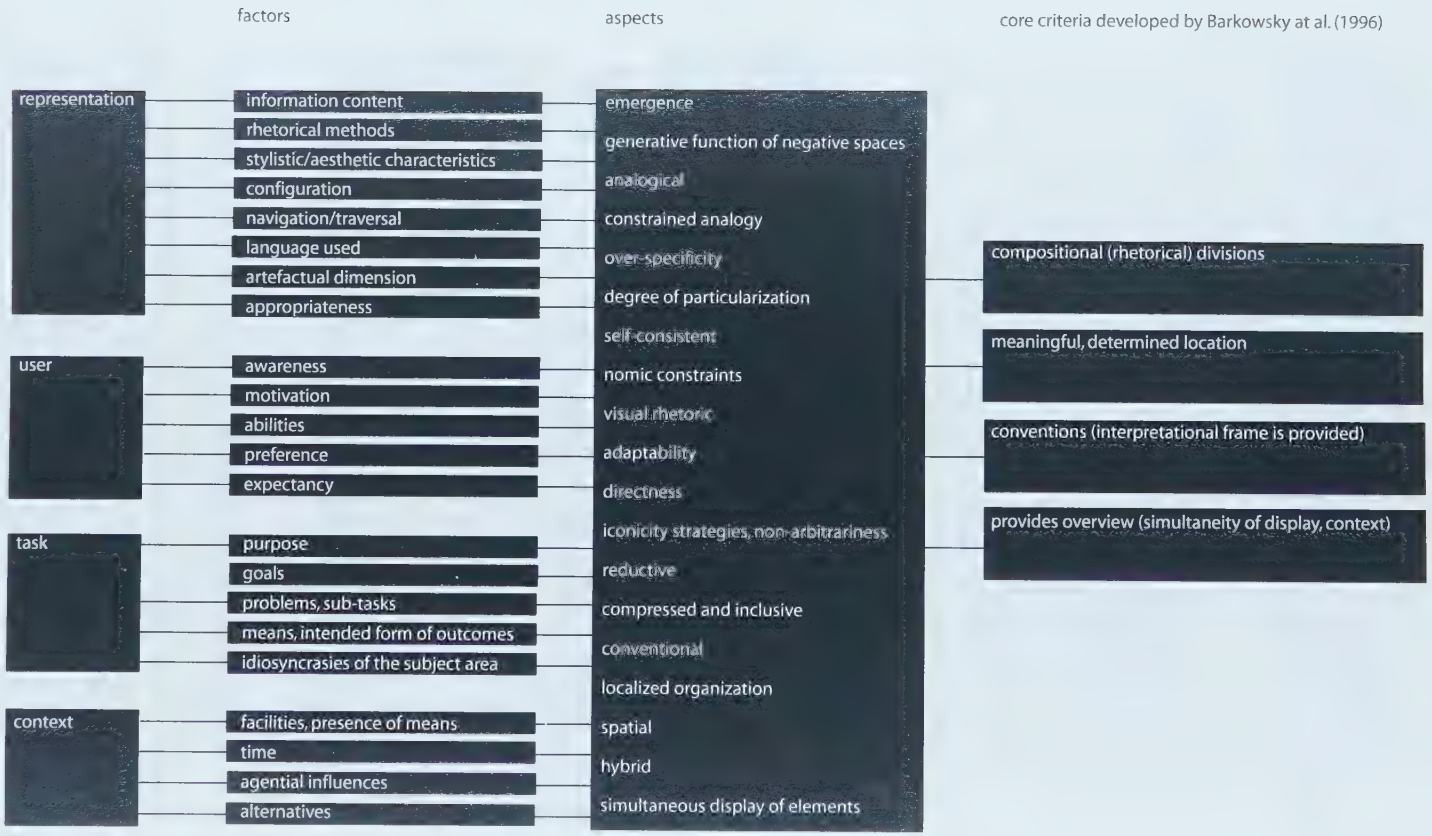
problems. The framework provides a ready-made set of broad categories of inquiry and open possibilities of extension, with which to approach any instance of visual representation. Situational conditions, which enable the appearance of certain characteristics, can be studied and described by the list of situational factors, and finally diagrammatic aspects. All factors contributing to the provision of diagrammatic qualities are ordered in groups referring to the representation itself, the user/perceiver, the task, and the context.

The presented framework is:

- gradual (allows for a continuum between weak and strong diagrammatic representations);
- plural in the sense that there is no distinctive attribute which accounts for diagrammaticity of a given situation;
- and relational (there are particular inter-relations among aspects and their attributes result in emerging qualities) (Shimojima, 2002, p. 14).

The diagrammaticity of a particular visual representation is a result of interconnected, complementary, and cross-affecting coomponets. It can be imagined as an open space of potentialities constrained and biased by developed terms (Delin et al. 2002/2003; Twyman, 1985, p. 248). The proposed framework discussed in detail below is only one possibility, one instance of embodiment of the diagrammaticity concept in operational way. Its character is open and can be easily extended further by adding new factors (*see Figure 7*).

Figure 7 .An explanatory diagram of the components of the framework one possible embodiment of diagrammaticity concept.



3.1.1 Components of the framework – aspects

Aspects indicate diagrammatic properties of representation enabled by the interplay of main situational components. Particular aspects should be considered as a result of larger situational circumstances. Following is a list of aspects.

Emergence in visual representation

The notion of emergence refers to the phenomenon that very often the whole (the unity) is not only a simple sum of features of its parts but exhibits new qualities not previously detected or unseen. The example from the field of Human Computer Interaction (HCI) shown below (*see Figure 8*) suggests that an overview will exhibit new qualities not previously manifested in a mass of separate pieces of data. In the case of diagrammatic representation, when expressivity of diagrammatic representation is strong (i.e. the representation is highly analogical), unplanned new information about the represented situation can be revealed.

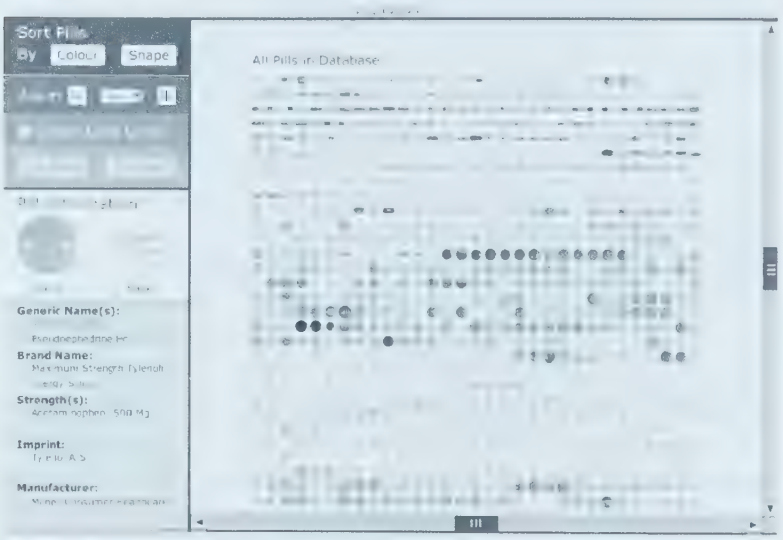


Figure 8 Pill identification interface prototype shows how ordered aggregation of separate pieces of data (pills' images) can reveal additional information, for instance, about relative frequency of using certain colors to together with shapes for pills' identification (example taken from Ruecker and Liepert, 2006, p. 241).

Generative function of negative spaces

Negative spaces are gaps in visual models that could result from lack or inaccuracy of data, lack of examples to fit a conceptual model, or point to shortcomings of the model itself (Ruecker and Liepert, 2006). Negative spaces in visual representation are an important device that can help to detect errors in original data sets, indicate that data presented are inaccurate or incomplete, point to areas of knowledge, which may need further elaboration, re-thinking or even can open new paths for research.

Analogical character of representation

A representation is analogical when it can denote properties and relations of parts in a represented configuration without referring to conventional symbols denoting relations (Sloman, 1971, p. 216 as cited by Shimojima, 2001). This means that the representing structure matches to some extent the structure of data being represented. Subjects from the represented configuration should be displayed by somehow 'similar' elements (Kulpa, 2004, p. 37). Strongly analogical representations have a property of self-consistency and non-arbitrariness (Kulpa, 2004, p. 37). The degree of analogy in representation is called its expressivity.

Constrained analogy

Although a high level of expressivity (which is a degree of analogy in visual representation) is a welcome feature of visual representation, a so-called constrained analogy has some important implications that have to be addressed. Shimojima (2001) called this attribute a "limitation on expressivity." Constrained analogy in diagrammatic representations may result from different sources, for example, graphical constraints (inherent features of modality, such as a two-dimensional plane, paper etc.) or from an inexact match between the represented structure and the visual structure allowed by the representation. Representation with limited expressivity allows the user to draw more controlled inferences provided that the user knows the limitations, and that the limitations on expressivity are "exploitable" (Shimojima, 2001, p. 16). This notion complies with the practical knowledge that simple but mastered tools (referred to as "cognitive availability of the limits") allow better efficacy than complex ones, which are not fully controlled. Once the readers of a graphic representation understand how to interpret the representation, they can also begin to take advantage of constraints of the system.

Over-specificity – visual representations compel specification of information

Shimojima (2001) noted that "[g]raphical representations cannot present some information set in a certain way without presenting one of the alternative pieces of information." (p. 22).This is especially problematic while a certain level of generality should be kept in a particular instance of information display. For a novice reader, each element can have potentially a constitutive character in terms of interpretation, even those not intended for decoding. For an experienced user, the same elements would be incidental and marginal in the process of apprehension (Waller, 1987, p. 119).

Degree of particularization

It seems self-evident that visual representations would tend more to particularization than make general statement about represented situation.

Diagrammatic representations, however, do allow the designer, through different strategies of generalization (e.g. schematization, conventionalization, localization), to present the subject matter in simplified form and turn the user's attention to important features. On the other hand, particularization has important implications for utilizing the method of divergence in processing information. It is based on the possibility of efficient presentation of multiple variations of problem processed until an intended result is achieved.

Self-consistency

This aspect refers mainly to matching the constraints of representation with the constraints of represented configuration. Barwise and Etchemendy (as cited by Shimojima, 2001) pointed out that diagrams as physical objects have their own set of constraints coming from conditions they must obey (eg. the way they are displayed). By using an appropriate choice of representation schema to express intended situation, so that constraints of representation and represented are matched, the diagram can show a lot of interesting information about a situation without as much effort. "The user can simply read off facts from the diagram as needed" (Barwise and Etchemendy, as cited by Shimojima, 2001).

Visual rhetoric

Diagrammatic representations rely on the visual representation of an argument. Rhetorical strategies of presentation (such as overview, development, partitioning, emphasis, relationships of different kinds) are realized through visual methods that may include applying gestalt principles, iconicity strategies, localization and more (Bernhardt, 1985).

> "When a writer elects to make a text visually informative, the decision has consequences which extend down through the text to all levels of structuring, from the large rhetorical divisions of the text, to the intersentential strategies of cohesion, to the syntax of individual clauses."
> (Bernhardt, 1985, p. 19)

It is based on observations about how textual and graphic components interweave to create a cohesive rhetorical structure to communicate in a specific situational context. Bernhardt listed "levels of rhetorical control" and found out how they could be supported by the visual organization of written text. The same list of "levels of rhetorical control" was examined in the case of documents, whose coherence is based on non-visual strategies, but lead to similar rhetorical results. Furthermore, this comparison enables the differentiation of more or less visually informative documents among given examples according to given categories of analysis (i.e. rhetorical strategies).

Figure 9. This example, taken from the book The Architecture Pack and reproduced by Wildbure and Burke (1999) could illustrate to a certain extent the notion of the aspects of nomic constraints. Although paper is not concrete, and original buildings are not supposed to fold, these pop-up visualizations bring the reader closer to the laws governing three dimensional world. Interestingly, Wildbure and Burke used the words paper *engineer* to introduce the designer of this book, Ron van der Meer, in a caption accompanying the illustration.

Nomic constraints

The notion of nomic constraints, in the context of visual representation, refers to the characteristic of representation resulting from non-arbitrary, "natural" laws of the domain represented. Nomic constraints are obeyed when, as noted by Feeney and Webber (2003, p. 213), "diagrammatic conventions and representing data (...) are faithful to the constraints that operate in the domain that is being represented." (*see Figure 9*). Their significance is supported by studies conducted by Gattis and Holyoak and Cheng, reported by Feeney and Webber (2003), who provided evidence that "adherence to nomic constraints facilitates learning and reasoning about a domain and may be one of the factors that make pictures more efficient than sentential representations." (p. 213) These findings might have important implications for design of highly analogical representations and the ways of interaction with them, for instance as proposed in the direct manipulation model of interaction in interface design (Shneiderman, 1997).

Adaptability

This attribute relates to the features allowing possible extensions to be added to representations as new layers of information or details become available. This quality was also reported indirectly by Ruecker and Liepert (2006) as one of the principles found in the working method of Mendeleyev, while preparing his periodic table of elements. They referred to it as multiple matrices for pattern finding, based on the constant re-arrangement of data until a coherent whole emerges.

Directness

Directness is a special instance of analogy. Richards (2002) referred to this feature through the notion of literal correspondence. According to his definition, literal correspondence takes place when the spatial relations of the situation to be represented are depicted by the spatial relations in visual representation. The directness of such mapping is one of the most important strengths of diagrammatic representations. This is in contrast to linguistic representations in which more complex syntactic structures are specified by 'abstract syntax' graphic representations in general. Diagrams in particular have diversity of spatial relationships that can be interpreted in a more direct way (Shimojima, 2001, p. 10).

Iconicity strategies, non-arbitrariness

Represented elements and configurations that rely on iconicity strategies are able to be interpreted more or less directly, i.e. without mediation by arbitrary symbols. Directness is one possible strategy (i.e. a diagram depicts the situation by representing spatial properties and relations of elements by spatial properties and relations of the diagram elements). Another example of iconicity strategies going beyond literal correspondence could be mapping a time sequence of actions on subsequent elements displayed from left to right. Another example showing how iconicity can work is shown below (*see Figure 10*).

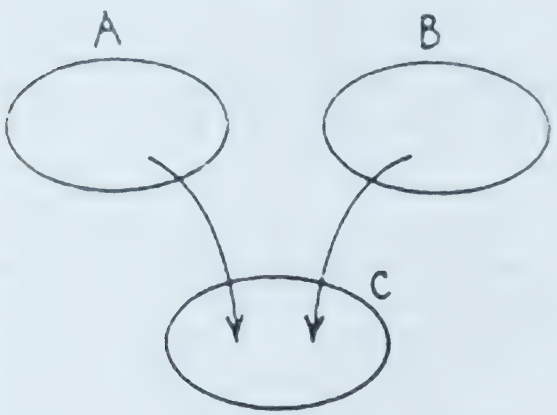


Figure 10.

It was an illustration to the discussion about figurative and non-figurative modes of depiction in diagrams by Richards (2002). He wrote:

> "It may be noted that even in very highly schematised diagrams there still may be faintly figurative elements. For example, (...) the curved flowlines may be perhaps more appropriate than if they had been angular, although both styles would express the idea of linking in some way. The curves suggest a pouring in, curves being a characteristic of fluids tipped from one vessel to another. Sometimes

vestiges of resemblance can be difficult to completely remove, and indeed their deliberate use can often be helpful in prompting appropriate interpretations by readers." (Richards, 2002, p. 90)

Although the interpretation provided by Richards was meant to illustrate how figurative elements are interwoven into schematized representation, it also serves as an example of iconicity. It works by referring to our knowledge derived from every-day activities to enhance understanding. For example, if a diagram depicts an activity of pouring fluids (we do not really know what this means), it would be useful to refer to the above attribute of obeying nomic constraints.' To better understand the presented subject matter, the representation is composed to recall the perceiver's knowledge about natural laws to be obeyed while pouring water.

Reductivity

This attribute of visual representation refers to a level of detail provided in depiction. For instance, diagrammatic representations enable a restricted amount of details which can be adjusted appropriately to a specific purpose.

Compressed and inclusive

This aspect was identified by Ruecker and Liepert (2006) in their analysis of Mendeleyev's table of elements. The compressed and inclusive aspect of visual representation may be observed when strategies of displaying data support including a wealth of information into a space-efficient form. The strategies include, among others: color-coding, abbreviations and different ways of display that take advantage of visual means of information presentation. The range of possibilities includes the seven graphic variables of Bertin's taxonomy: color, shape, scale, tonal value, texture, orientation, and location (as cited by Ruecker and Liepert, 2006).

Conventional

A particular visual representation is usually tailored to the specific disciplinary context. The variety, richness and complexity of information to be communicated compels the creation of area specific, conventionalized visual representations. For instance, there are many examples of specific diagrammatic systems constructed exclusively for certain tasks.

Localized organization for apprehension of information

Diagrammatic representations use extensively the feature of localization to focus users/perceivers' attention on particular elements, which stand for discrete units of information. The localized organization of content is the opposite to a progressive one, which assumes sequential, a priori ordered apprehension (Bernhardt, 1986). From a user's perspective, localized organization gives him/her more control over the sequence of apprehension of information (Waller, 1987).

Spatial representation

In spatial representations, a significant part of information is encoded by the position of the elements on the plane or in space in relation to other elements. Spatial properties allow many elements to be adjacent to many others (Shimojima, 2001). Spatial representation is an alternative to sequential, or in the case of text, "sentential" representation, which is characterized by the structure of data in which elements appear one after another and one element is adjacent only to the previous and next element in a sequence.

Hybrid

Hybrid representation employs different visual modes. In most cases, visual representation can support several interpretations unless accompanied by verbal language (Waller, 1987, p. 109). To allow for more precise interpretation, visually communicated information can be anchored in textual context. Diagrammatic representations often mix verbal, schematic or pictorial modes of symbolization according to the divisions provided by Twyman (1979) in his schema for the study of graphic language. Additionally, Ruecker and Liepert (2006) proposed that one of the principles involved in the creation of Mendeleyev's periodic table was provision of a legend explaining rules of notation system developed for coding information. The consistent system of codifying information (in the schematic mode) and efficient way for explaining it (in the verbal mode) allowed compression of rich information in efficient visual form.

Simultaneous display of elements

Elements of represented configuration are simultaneously visible and available to the perceiver for inspection. The user can immediately identify and assess the relationships present in the situation depicted. Simultaneous display allow for the distinguishing of different structures across a rich scope of available information and identification of meaningful patterns.

3.1.2 Components of the framework – factors

The framework, created by mapping interconnections of aspects and factors, emphasizes the circumstances that influence how diagrammatic representation works. Factors refer to a description of a situation follow the models discussed by Twyman (1985), Waller (1987), Delin et al. (2002/2003) and Ruecker (2004). They are meant to provide a structure, which would address a possibly exhaustive set of components of the overall situation in which a visual representation could be involved.

The factors are meant to detail the four main facets of a situation: main situational components regarding users, visual representations, tasks, and contexts. The proposed framework comprises the following factors.

Factors relating to the visual representation

- *Information content* refers to the information to be communicated possibly distinguished from rhetorical methods.
- *Rhetorical methods* refer to how the content is argued. especially relevant for the purpose of this research are methods of visual rhetoric or its combination with verbal elements to create a cohesive communication.
- *Stylistic/aesthetic characteristics* offer choices in visual representation. no visual representation is neutral in this respect. a proper choice can provide advantages as much as a wrong or unconscious decision can spoil the overall quality of representation.
- *Configuration* refers to the way the visual representation is composed/ arranged.
- *Traverse/navigation* covers features related to the sequence and possibilities of how the information is revealed in visual representation.
- *Language* used relates to features of verbal component of representation.
- *Artefactual dimension* refers to all features arising out of the technical aspects of medium used, such as the means of production and the way of displaying.
- *Appropriateness* covers the description of physical, environmental, social suitability of representation.

Factors relating to the user

- *Awareness* reflects a user's perception of the possibility that visual representation can be approached as potentially capable to exhibit diagrammatic qualities.
- *Motivation* encompasses reasons, which guide the activity of the user. The user's motivation can be quite different than the purpose of the task, which can be only a step in achieving the other goal. Motivation is an indispensable criterion of successful communication. Reasons for using a visual representation in specific way should be sound and well planned. Although visual representations are able to significantly facilitate work, this is not necessarily so in all circumstances. False emergence in diagrams or inaccuracy of drawing could significantly undermine the credibility of diagrammatic representations.
- *Abilities* refers to the user's capacities to recognize the qualities of visual representation. Some characteristics that can be recalled are familiarity with different methods of presenting information visually, first hand experience with using and producing visual messages, sensitivity in perception of details, ability to interpret directly as well as metaphorical representations.
- *Preference* can stem from previous experience, aesthetic qualities of the representation or influences of the environment or of other people involved, so the factor can be studied as comprising several sub-factors. The

user's background is influential in terms of prior knowledge, represented discipline, etc. Preference can also influence the way the information is presented and processed. This is critical when a choice has to be made from several available alternatives.

- *Expectancy* points to what is anticipated by the user in an encountered situation. It can influence the overall usefulness of visual representation. Encountering unanticipated information or unexpected way of presenting information could be distracting for the user. On the other hand visual representation, which fully conforms to expectations, can close possibilities of a creative or motivating viewpoint on the issues presented.

Factors relating to the task

- *Purpose* all describe general aims that are attached to the task.
- *Goals* are specific outcomes that are supposed to be achieved.
- *Problems and sub-tasks* refer to partial obstacles that have to be overcome, or decisions that have to be made to achieve main goals. They are not really connected to the goal but have bearing on the means of achieving it. They can refer to particular decisions made regarding, for instance, the sequence of steps, which need to be followed or decisions about the specific use of a representation in attempt to gain an intended outcome. Careful planning and analysis of goals can provide a fairly detailed sub-task list facilitating task management.
- *Means and intended form of outcomes* cover the physical conditions planned for task completion and the final embodiment of results. Further elaboration of this factor will show to which extent it overlaps with factors referring to artefactual dimension of visual representation under consideration.
- *Idiosyncrasies of the subject area* recognizes that the same task can be realized in many sometimes very distinctive ways. Again, the user's background and the disciplinary context can have strong impact on the way the task is formulated and executed, and the results presented.

Factors relating to the context

- *Facilities and presence of means* are concerned with available resources, for instance required for task completion.
- *Time* is a very important factor, which can affect all the other factors. It may refer to the time, which is available and constrained by circumstances.
- *Agential influences* refer to others involved in situation, who have their own "agency."
- *Alternatives* point to the possible presence of alternate solutions available for use in the environment.

4. CONCLUSION

The discussion presented in this document was just the first step in establishing a set of interrelated terms: aspects, situational factors, and their description. The framework provided a structure, still more or less vague, to think about diagrammaticity, i.e. possible interrelations of components of the situation resulting in diagrammatic qualities of representations involved. This is in fact a meta-framework enabling construction of problem-specific frameworks.

General advantages of the proposed approach:

1) The concept of diagrammaticity was proposed as useful to encompass the idea, that all visual representations can be thought of as diagrammatic.
2) Terminology, important for the discussion on diagrammatic representations, was identified.
3) The framework was proposed as a way to "operationalize" the concept of diagrammaticity by enabling structured exploration of visual representations according to provided aspects and factors.
5) The approach covered a broad array of points of view, but at the same time did not assume completeness. The research behind the framework revealed always presented the bias of a researcher attempting to build the framework for certain purposes. In fact the framework promotes a conscious bias encouraging its adoption to different circumstances.
7) It provided a scaffolding for exploration of decisive features of diagrammatic representations in specific situations (enable to construct problem based frameworks).
6) The framework provided with a ready to use check-list of information about gathered examples of visual representations. It pointed to details of contextual information, which otherwise could escape attention.

The agenda for the next phases of research would include:

1) Construction of problem-specific frameworks based on a provided set of aspects and factors.
2) Conducting studies of real-life examples of visual representations to explore the framework flexibility to study a particular, narrowed topic.

2) Further clarification of terminology.
3) Mapping aspect and factor relationships based on conducted studies of visual representations.
4) An interesting aspect would be a cross-disciplinary comparison of instances of a particular aspect, how it is realized in different contexts.
5) Additionally, more interviews and mini group discussions with potential users (students, designers) are necessary for further elaboration of the framework.

When all the information has been collected and related to each other in a preliminary way, the next crucial step would be to conduct a series of studies in the real-life contexts. Well-documented studies involving application of the framework should enable us to match specific contexts with characteristic aspects and factors contributing to emerging diagrammatic qualities. It is believed that the study of a greater number of visual representation examples will result in the optimization of the framework components.

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6. APPENDICES

Ethics application

Examples from M. Twyman's schema

Final visual presentation

Ethics application

University of Alberta
Faculty of Arts, Science & Law Research Ethics Board

Application to Conduct Research Involving Human Participants

Principal Investigator(s): Name: Piotr Michura, Master of Design (MDes) Candidate
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Project title

Diagrammatic representations: an analytical framework for visual communication design students.

Funding Source(s) n/a

Summary of Project / Research Design

[Please attach a more detailed proposal (i.e., 1-2 pages), including a description of the population from which research participants will be drawn (e.g., university students, nursing home residents) and a discussion of how research participants will be solicited. Also attach copies of research instruments (e.g., questionnaires, interview guides)]

The objective of the thesis research is to develop an open framework that can serve as a learning aid for design students working on and with diagrams. The framework will take the shape of a computer-supported tool enabling a multivariate management of collected examples of diagrams for supporting referential, analytic and generative functions in the diagram design process.

Diagrams are a unique means of communication as they bridge the gap between visual and verbal modes of representation. They have great potential as highly efficient tools to map and manipulate complex, multi-connected structures of data in order to build new ideas and concepts. Parallel to the expanding use of digital media, the interest in diagrammatic representations is increasing even in the fields traditionally associated with purely textual methodology of research. Diagrammatic representations freed by digital technology from the constraints of the printed page provide new possibilities for effective communication. The research is an attempt to map current trends in diagrammatic representations being used across different fields, to reveal relationships between emerging and already well established kinds of representations, and also to test relevant means of recording and describing these representations for research purposes.

Within the visual communication design discipline, it is critical to equip students with a framework to enable them to embrace the different potentialities of diagrammatic communication today. Through interaction with the proposed framework, students will be able to gain an overall view of the possibilities of diagrammatic language to increase their analytic abilities, and to apply knowledge through practical exercises.

The current study has three parts and is designed to collect data from researchers, practitioner, and educator from different fields, visual communication design instructors and visual communication design students.

Part I: Researcher, practitioner, and educator interview

Consultations with researchers, practitioners and educators from a variety of fields including design, humanities computing, psychology, engineering, and education are important to explain how the framework can support a broad spectrum of approaches towards diagram creation and use. The literature survey shows that attitudes towards visual modes of representation may differ significantly across different fields. Researchers/practitioners/educators will be asked about formal and informal visual representations used within an academic scene and outside of it in their field of expertise. Participants will be invited to explore verbally their working processes, identify and reflect on visual means used for producing and sharing knowledge, traditions, current conventions, and purposes of diagrammatic representations being used within each participant's field. The initial concept of the framework will be presented to them, and discussed to understand what are the desired features of the framework and anticipated benefits in the context of participant's field.

Part II: Visual communication design instructor focus group session

The focus group with visual communication design program instructors would investigate the possible benefits for the educational process in the design field when using the proposed framework. Discussion with the instructors is crucial to exploring how the framework could fit into the broader context of curriculum, assignments, and other learning resources currently being used and to collect opinions about the framework itself in terms of its concept and form.

Part III: Visual communication design student focus group session

The meeting with visual communication design students will elicit feedback from this group of possible users asking to comment on the proposed solution presented in the form of a paper prototype. The students will be encouraged to share their opinions about the concept of the framework, expected benefits from using the framework and the most suitable features of its interface. The main goal is to ensure that the framework meets students' needs.

Assessment of Risk to Human Participants

[Attach additional page(s) if necessary]

Data will be collected in three parts for this study. Five to fifteen researchers, practitioners, and educators, three to five instructors and ten to fifteen visual communication design students will be recruited. Researchers, practitioners, educators, and instructors will be recruited by e-mail; students – through posters displayed in a common space.

This study consists of individual, semi-structured interviews with the researchers, practitioners and educators and focus groups with instructors and students. All of them previously would have agreed to participate. Throughout the data collection process, participants will not likely to be exposed to situation, experience, instruction, or verbal/visual messages that they would not have previously experienced in a typical school situation.

Materials used during or for data collection will include an audio recording device, pencil and paper for note-taking purposes and materials used to create the paper prototypes of designed framework. The presented visual materials are not likely to offend, distract, or disturb any of the participants.

A research assistant will be present to help collect the data.

The interviews will last approximately 30 minutes each. The focus groups will last approximately 20 minutes each. All sessions will be audio-taped, transcribed, and coded for anonymity.

There is minimal risk associated with participation in this study.

Part I: Researcher, practitioner, and educator interview

The principal investigator will ask participants individually semi-structured questions about diagram use and their response to the initial framework. The risk associated with participation in this part is considered minimal.

Part II: Visual communication design instructor focus group session

Participants will be encouraged to discuss how the framework could fit into broader context of curriculum, assignments, and other learning resources currently being used and to share opinions about the concept and form of the framework itself. The risk associated with participation in this part is considered minimal.

Part III: Visual communication design student focus group session

Students will be asked to envision the possible process of use of the framework on the basis of a presented paper prototype and to discuss the concept and anticipated impact and benefits for their own design process especially when working on diagrams. Focus group session with students will occur outside of class hours, and instructors will not know who, among their students, is going to take part in the session. The risk associated with participation in this part is considered minimal.

Description of Procedures to be Undertaken to Reduce Risk to Human Subjects

[Please attach copies of consent forms and other similar documents]

All participants will be informed that participation is voluntary and that they may leave at any time without penalty. Each participant will be informed about the purpose and nature of the research project and ask to sign the consent form (see attached) if they wish to participate. In

addition, participants will be given the opportunity to ask questions about the research before signing the consent form.

Students will not be coerced in any way to participate in this study. Students will be told that participation in this study is voluntary, and not associated with their class, grades or any other evaluation associated with their program. Instructors will not be told about which of their students are taking part in the study. Students must be at least 18 years old to be eligible to participate.

Participant recruitment

Researcher, practitioner, and educator participants
Participants will be recruited through e-mails (see attached) sent to them directly. The invitations will be sent to potential participants asking them to participate in individual interviews. Invitation will provide a brief explanation of the purpose and nature of the research. Additional details will be provided by e-mail, if potential participants contact the investigator regarding the study.

Instructor participants
Selected instructors will be sent a letter (see attached) asking them to participate in a focus group session and outlining the research project. In case of any question additional details will be provided by e-mail.

Student participants
Recruitment will involve a poster advertisement (see attached) placed in the common area. The poster will request volunteers, describe the type of research and eligible participants, outline research topic, show dates for testing and provide with contact information.

Data collection and privacy of information

The interviews will be audio-taped, transcribed, and coded for anonymity.

As a nature of focus groups requires work with a number of people together, complete anonymity is not possible to be kept. However, all participants will be asked not to share the content of other's comments outside the focus group meeting. Each session will be audio-taped, transcribed, and, after the session is completed, coded for anonymity for further uses in a MDes thesis report, thesis exhibition and possibly in related papers and presentations

The paper and pencil notes will be taken by the principal investigator and by a research assistant as well. All data and personal information the participants provide will be considered completely confidential. The participants' identities will remain anonymous.

The data collected in this research project will be used in a MDes thesis report, thesis exhibition and possibly in related papers and presentations.

Data will be handled in compliance with the University of Alberta Standards for the Protection of Human Research Participants. All interview data, including tapes, transcripts, and written notes, will be kept in a secure location for at least five years. When the project is complete, the data will be destroyed.

I have read the UNIVERSITY OF ALBERTA STANDARDS FOR THE PROTECTION OF HUMAN RESEARCH PARTICIPANTS [GFC Policy Manual, Section 66] and agree to abide by these standards in conducting my research.

_____ Signature of Principal Investigator(s)

_____ Date

(If Student)

_____ Signature of Faculty Supervisor/ Sponsor

_____ Date

Dr. Lynn Penrod, Chair
Arts, Science, Law Research Ethics Board
Office of the Dean of Arts
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Phone: 492-3584
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Appendices

I. Research program

II. Recruitment materials

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I. Research program

The objective of the thesis research is to build an open framework that can serve as a learning aid for design students working on and with diagrams. The framework will take the shape of a computer-supported tool enabling a multivariate management of collected examples of diagrams.

Diagrams are graphic representations designed purposefully to communicate the ways data are interrelated by both their physical arrangement and symbolic meaning. As stated by Frascara (2001), diagrams have a great potential as highly efficient tools to map and manipulate complex, multi-connected structures of data in order to build new ideas and concepts. Diagrams are unique as they bridge the gap between verbal and visual modes of representation – traditionally strongly distinguished by a scholarly tradition of knowledge production, typically dominated by texts in opposition to images (Storkerson 1992). However, parallel to the increasingly extensive use of digital media, the interest in diagrammatic representations seems to increase even in the fields traditionally associated with purely textual methodology of research as, for instance, in literary studies (Drucker 2004).

Diagrammatic representations freed by digital technology from the constraints of the printed page can provide new possibilities for effective communication. This research is an attempt to map current trends in diagrammatic representations being used across different fields. The framework will reveal relations between emerging and already well-established representations and enhance our understanding of activities and supporting diagrammatic tools for working effectively with complex data within the broad array of disciplines. In this regard, the most important challenge for the concept of the framework is posed by rapidly changeable, dynamic contemporary sphere of visual communication. The research will allow the testing of relevant means of recording and describing these representations for research purposes and practical applications.

Visual communication designers, researchers, educators, and above all students could contribute to the creation of new diagrammatic representations using the framework as a thinking tool to serve practitioners from other fields as effective means for exposing, analyzing, and solving problems they face.

General impact

I anticipate that this research will have a significant impact on the following three main areas of activity within the design field – design practice, research, and education – especially with regard to diagram design.

Design practice
a) providing a common platform and language to discuss possible solutions with clients;
b) organizing and supporting the analysis of a designer's own collection of visual material connected with a project; and
c) serving as a thinking tool for generating new ideas.

Design research
a) enabling broad, cross-disciplinary comparisons and generalizations based on analyses of gathered examples;
b) enabling a broad overview to detect patterns across fields;
c) providing organizational principles for gathering examples; and
d) supporting the creation of conceptual frameworks.

Design education
a) training design practitioners and researchers (which encompasses to certain extent *design practice* and *research*); and
b) guiding teaching and learning processes.

Focus on design education

Within the discipline of visual communication design, it is critical to equip design students with a framework to enable them to embrace the different potentialities of diagrammatic communication today. The work of a visual communication designer is interdisciplinary and often demands collaborating with professionals from other fields or responding to the needs of clients coming from other areas of expertise. To be able to react flexibly and efficiently to new tasks and communicate easily with or to people across disciplines, the designer must develop visual literacy grounded in a rich set of meaningful examples ordered according to a coherent theory. The main goal of this research stems from recognition of the importance of building the common language between practitioners of various disciplines and designers using diagrams as the one of possible ways of communication.

Research question

The research presented here concerns the two-fold issue of building a coherent framework and its suitability for a design educational environment. To structure the research process, the following research question was formulated: *How can an analytical framework for the study of diagrammatic representations be developed as an educational resource for visual communication design students?*

Research methods

There are eight steps designed to provide the design students with concise, accurate, and open framework that can be used in educational setting as a tool supporting practical work on projects as well as theoretical investigations into the realm of graphic language:

1. Analysis of visual examples of diagrams acquired from a variety of sources using a principle--based approach.
2. Literature review of examples of different graphic language frameworks and general discussions about classifications of visual materials.
3. Literature review of principles guiding the design of educational resources.
4. Building an initial framework for diagrammatic representations.
5. Studies involving participants: semi-structured interviews, focus groups.
6. Reformulating the framework according to results from previous studies.
7. Designing the interface prototype.
8. If time allows, testing the interface prototype. (If so, an addendum to the ethics application will be submitted)

Studies involving participants

The crucial element of the research program is to conduct studies involving participants through a series of semi-structured interviews and two focus groups. The main idea behind this approach is to get a variety of opinions on the proposed solution from groups of people who could be directly or indirectly influenced by the proposed framework.

Part I: Researcher, practitioner, and educator interview

Consultations with researchers, practitioners and educators from a variety of fields including design, humanities computing, psychology, engineering, and education are important as a way to make sure that the framework supports and reflects a broad spectrum of approaches towards diagram creation and use in the communicational context. A brief literature survey shows that attitudes towards visual modes of representation may differ significantly across fields.

The study is planned as exploratory research aiming to map an initial terrain for gaining the knowledge about diagrammatic representations used by professionals in their work with large/extensive amounts of data. Studying the creation and effect of diagrams in many fields will help to:
a) distinguish major features of diagrammatic representations;
b) define the phenomenon of diagrams in a broad context; and
c) overcome a bias of the researcher's own discipline in looking at diagrams.

It is valuable to investigate the use of diagrammatic means by researchers in disciplines, which have just begun to formally acknowledge the possible benefits of its use. The informative example comes from the relatively new field of Humanities Computing, which is in the forefront of the new conceptualization of visual forms of representation in humanities as a significant or even a primary tool for text interpretation purposes. The main shift could be seen in a theoretical approach, where an impact of visual forms on the process of producing knowledge have started to be appreciated and acknowledged – i.e. the understanding that information and its visual embodiment are not separate and independent but act together as a factor in a complex process of the interpretation of a given textual artifact.

On the opposite end of the spectrum one can find domains that are very closely tied to visual means of working. Visual communication design researchers and practitioners promote constantly the conscious use of visual methods and techniques in communication on the basis of extensive interdisciplinary research. They themselves tend to use and teach to utilize visual materials and means at all stages of design process. Within the body of research concerned with design practice, the important questions are posed about the significance of visuals for instance in the conceptual phase of design process (Arnheim 1993, Keller 2005, Twersky 1999). The main issues addressed include studying to what extent practitioners consciously acknowledge the importance of using visuals in thinking, on what premises is it based, how do they use visuals in everyday practice.

The interviews will include three main activities:
a) exploring traditions, current conventions, and purposes of visual language being used within the participant's field;
b) introducing the concept and initial visualization of the designed framework to discuss possible benefits in the context of the participant's field; and
c) discussing new possible future approaches to diagram use in the participant's field using as a point of departure the examples from the framework.

Part II: Visual communication design instructor focus group session

The more general approach in Part I, aimed at mapping the current position of diagrammatic representation in a rich, multidisciplinary context, will be followed by the study about the possible benefits of proposed framework for the design field in educational environment. The

focus group composed of instructors involved in teaching in visual communication design would discuss how the framework could fit into the broader context of teaching practice, curriculum, assignments, and other learning resources currently being used in classes. It would be of special importance to consider possible scenarios of instructions involving active use of the proposed framework.

It is essential to get an insight about the attitudes towards this kind of educational tool from important and influential group of potential users of the framework.

Part III: Visual communication design student focus group session – concept and paper prototype testing

Another group of users, visual communication design students, will be asked about the concept of the framework, expected benefits from using it and the most suitable features of its interface. A paper prototype will be presented to visual communication design students to elicit responses to the proposed solution. The effectiveness of the prototyped framework will be studied by analyzing students' responses to given tasks when using the framework. Another aspect of the study would be to find out what is the influence of visual aspects of prototyped framework on the working experience of participants. The main goal is to ensure that the framework meets students' needs.

Summary

The interdisciplinary nature of my research aimed at providing design students with an open framework for studying diagrams requires broad consultations with practitioners from different fields of knowledge. The overall view of practical application of diagrams in everyday research work should be conceptualized through detailed analysis and synthesized by imposing a general order. This synthesis stage of the research seems to me the most demanding and challenging. The result of the research – the framework – is intended to help visual communication design students to provide practitioners from different fields of research with effective methods for representing, analyzing, and solving problems by visual means of diagrammatic representation.

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II. Recruitment materials

Recruitment poster

Hello everyone. My name is Piotr Michura. I am a graduate student in Visual Communication Design program at the Department of Art and Design, working on my final thesis research.

The objective of the thesis research is to build an open framework that can serve as a computer--based learning aid for design students working on and with diagrams. This will help the students to gain an overall view of the possibilities of diagrammatic language, increase their analytic abilities, and use efficiently the knowledge in practical exercises.

I would like to invite you to participate in my thesis research and to help me in my work by sharing your opinions and experience. Your role will be to take part in a focus group discussion related to the question of how can a computer-based analytic framework for the study of diagrams be developed as an educational resource for visual communication design students. I will present a paper prototype asking you to comment on the proposed solution, the concept of the framework, expected benefits from using the framework and the most suitable features of its interface. The main goal is to ensure that the framework fulfills the above mentioned objective and meets students' needs.

Participation is voluntary and you are free to withdraw from the study at any time without penalty. All personal information you provide will be considered completely confidential. The participants' identities will remain anonymous. The data collected in this research project will be used in a MDes thesis report, thesis exhibition and possibly in related papers and presentations. The focus group session will occur outside of class hours, and instructors will not know who, among their students, is going to take part in the experiment. It will not be associated with your class, grades or any other evaluation connected with your program.

If you are interested in participating, the session will last approximately 20 minutes and will be held in one of the classrooms. There are three possible dates of the focus group session (please chose the most convenient for you):
1) .....at .....
2) .....at .....
3) .....at .....
Please contact me, using the information below, if you would like to participate in this study. Let me know which session date is the most suitable for you. I will contact you to confirm the final arrangement.

Your interest in this study is highly appreciated. Thank you.

Piotr Michura

For more information, please contact my supervisor Bonnie Sadler Takach, Assistant Professor, Department of Art and Design, at 492-5092 or sadler.takach@ualberta.ca

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Piotr Michura, MDes Candidate
Department of Art and Design
E: pmichura@ualberta.ca
P: (780) 492-7877

E-mail to Researcher, Practitioner or Educator Requesting Participation

Dear [individual's name],

I am a graduate student in the Visual Communication Design program at the Department of Art and Design, University of Alberta. I am preparing my Master of Design thesis under the supervision of Bonnie Sadler Takach, Assistant Professor, Department of Art and Design.

I am writing to ask you if you might be able to take part in my thesis research and to help me by sharing your opinions and expertise in the subject matter of my planned thesis.

The objective of the thesis research is to build an open framework that can serve as a learning aid for design students working on and with diagrams. The framework will take the shape of an interactive computer-supported tool enabling a multivariate management of collected examples of diagrams. Through interaction with the proposed framework, students will be able to gain an overall view of the possibilities of diagrammatic language, increase their analytic abilities, and apply knowledge through practical exercises.

Consultations with researchers, practitioners and educators from a variety of fields are important for me as a way to make sure that the framework supports a broad spectrum of approaches towards diagram creation and use. The literature survey shows that attitudes towards visual modes of representation may differ significantly across different fields.

The semi-structured individual interview will consist of questions about formal and informal visual representations used within an academic scene and outside of it in your area of expertise. You will be invited to explore verbally the working process, identify and reflect on visual means used for producing and sharing knowledge – traditions, current conventions, and purposes of diagrams being used within your field of expertise. The initial concept of the framework will be presented and discussed to understand what are the desired features of the framework and anticipated benefits in the context of your area of expertise.

I anticipate that the session will lasts approximately 30 minutes. The interview will be audio--taped, transcribed and coded for anonymity.

Thank you for your attention to my request. Your interest in this study is highly appreciated.

I am looking forward to hearing from you.

Sincerely yours,

Piotr Michura

Ps. For more information, please contact my supervisor Bonnie Sadler Takach, Assistant Professor, Department of Art and Design, at 492-5092 or sadler.takach@ualberta.ca

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Piotr Michura, MDes Candidate
Department of Art and Design
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E: pmichura@ualberta.ca
P: (780) 492-7877

E-mail to Instructors Requesting Participation

Dear [instructor's name],

I am a graduate student in the Visual Communication Design program at the Department of Art and Design, University of Alberta. I am preparing my Master of Design thesis under the supervision of Bonnie Sadler Takach, Assistant Professor, Department of Art and Design.

I am writing to ask you if you might be able to take part in my thesis research (as a member of a focus group) and to help me by sharing your opinions and expertise in the subject matter of my planned thesis.

The objective of the thesis research is to build an open framework that can serve as a learning aid for design students working on and with diagrams. The framework will take the shape of an interactive computer-supported tool enabling a multivariate management of collected examples of diagrams. Through interaction with the proposed framework, students will be able to gain an overall view of the possibilities of diagrammatic language, increase their analytic abilities, and apply knowledge through practical exercises.

Consultations with instructors is extremely important for me to find how the framework could fit into broader context of teaching practice, curriculum, assignments, and other learning resources currently being used in classes. It would be of special importance to consult possible scenarios of instructions involving active use of the proposed framework.

Additionally, it is essential to get an insight about the attitude towards this kind of educational tool from important and influential group of potential users of the framework in the educational setting.

Your role will be to participate in a focus group session to discuss the issues connected with my thesis topic. The session will take approximately 20 minutes to complete.

If you are interested in participating, please contact me and I will arrange the focus group meeting at all participants convenience.

Thank you for your attention to my request. Your interest in this study is highly appreciated.

I am looking forward to hearing from you.

Sincerely yours,

Piotr Michura

Ps. For more information, please contact my supervisor Bonnie Sadler Takach, Assistant Professor, Department of Art and Design, at 492-5092 or sadler.takach@ualberta.ca

---

Piotr Michura, MDes Candidate
Department of Art and Design
University of Alberta
E: pmichura@ualberta.ca
P: (780) 492-7877

III. Informed consent forms

Part I: Researcher, practitioner, and educator interview

Introduction

You are invited to participate in a research project being conducted at the Department of Art and Design, University of Alberta.

The objective of the thesis research is to build an open framework, which can serve as a learning aid for design students working on and with diagrams. The framework will take the shape of an interactive computer-supported tool enabling a multivariate management of collected examples of diagrams. Through interaction with the proposed framework, students will be able:

a) to gain an overall view of the possibilities of diagrammatic language;
b) to increase their analytic abilities; and
c) to apply knowledge through practical exercises.

Your role in this semi-structured interview will be to share your knowledge about formal and informal visual representations used within an academic scene and outside of it in the field of your expertise. You will be invited to explore verbally the working process, identify and reflect on visual means used for producing and sharing knowledge – traditions, current conventions, and purposes of diagrams being used within your field. The initial concept of the framework will be presented and discussed to get to know what are the desired features of the framework and anticipated benefits in the context of your area of expertise.

This research is being conducted by Piotr Michura, a MDes candidate in Visual Communication Design program, and a research assistant.

If you choose to participate in this study, you will be interviewed for approximately 30 minutes.

This interview will be tape-recorded and transcribed. After removing any identifying information, these transcripts will be assigned an arbitrary code number to ensure your anonymity. Also, when reports of this research are presented in the MDes thesis report, and possibly in related papers and presentations, we may quote directly from these transcripts but only in a manner that maintains your anonymity.

Your confidentiality and rights

The researcher and assistant associated with this project will comply with the University of Alberta Standards for the Protection of Human Research Participants. Data recorded in the course of this research will be available only to myself, my supervisor, and my research assistant, who have signed confidentiality agreement. This study has been reviewed and approved by the University of Alberta Faculty of Arts, Science & Law Research Ethics Board.

I, (please print your name).....acknowledge, understand, and agree to all the following listed:

- I have been asked to participate in a research study.
- My participation in this study is voluntary.
- I have the right to withdraw from this study at any time, without penalty. If I opt out, the data collected in my interview will not be used in the study.

- I have the right to privacy, anonymity and confidentiality.
- All my information will remain confidential.
- My name and personal information will not appear on any materials.
- I may be quoted directly in the MDes thesis report, and possibly in related papers and presentations, although in a way that maintains my anonymity
- I have the right to have any data collected in this study kept in a safe, secure place.

Signature of the participant

Date

If you have any concerns about this research project, please contact:

Piotr Michura, MDes Candidate
Visual Communication Design
Department of Art and Design
Faculty of Arts
Campus Address: 3-71A FAB
Campus Phone number: 492-7877
E-mail address: pmichura@ualberta.ca

Prof. Bonnie Sadler Takach, supervisor
Visual Communication Design
Department of Art and Design
Faculty of Arts
Campus Address: 3-98 FAB
Campus Phone number: 492-5092
E-mail address: sadler.takach@ualberta.ca

Part II: Visual communication design instructor focus group session

Introduction

You are invited to participate in a research project being conducted at the Department of Art and Design, University of Alberta.

The objective of the thesis research is to build an open framework, which can serve as a learning aid for design students working on and with diagrams. The framework will take the shape of an interactive computer-supported tool enabling a multivariate management of collected examples of diagrams. Through interaction with the proposed framework, students will be able:
a) to gain an overall view of the possibilities of diagrammatic language;
b) to increase their analytic abilities; and
c) to apply knowledge through practical exercises.

Your role will be to participate in a focus group session to discuss the issues connected with my thesis topic to find how the framework could fit into broader context of teaching practice, curriculum, assignments, and other learning resources currently being used in classes.

The session will take approximately 20 minutes to complete.

This research is being conducted by Piotr Michura, a Master of Design candidate in Visual Communication Design, and a research assistant.

Because the nature of focus groups requires discussion with others in a face-to-face situation, complete anonymity is not possible. However, all focus group participants will be asked not to share the content of others' comments outside the focus group meeting.

The focus group discussion will be tape-recorded and transcribed. After removing any identifying information, these transcripts will be assigned an arbitrary code number to ensure your anonymity. Also, when reports of this research are presented in the MDes thesis report, and possibly in related papers and presentations, we may quote directly from these transcripts but only in a manner that maintains your anonymity.

Your confidentiality and rights

The researcher and assistant associated with this project will comply with the University of Alberta Standards for the Protection of Human Research Participants. Data recorded in the course of this research will be available only to myself, my supervisor, and my research assistant, who have signed a confidentiality agreement. This study has been reviewed and approved by the University of Alberta Faculty of Arts, Science & Law Research Ethics Board.

I, (please print your name).....acknowledge, understand, and agree to all the following listed:
- I have been asked to participate in a research study.
- My participation in this study is voluntary.
- I have the right to withdraw from this study at any time, without penalty. If I opt out, the data collected in my interview will not be used in the study.
- I have the right to privacy, anonymity and confidentiality.
- All my information will remain confidential.
- My name and personal information will not appear on any materials.

- I may be quoted directly in the MDes thesis report, and possibly in related papers and presentations, although in a way that maintains my anonymity.
- I have the right to have any data collected in this study kept in a safe, secure place.

---------- ----------

Signature of the participant Date

If you have any concerns about this research project, please contact:

Piotr Michura, MDes Candidate
Visual Communication Design
Department of Art and Design
Faculty of Arts
Campus Address: 3-71A FAB
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Prof. Bonnie Sadler Takach, supervisor
Visual Communication Design
Department of Art and Design
Faculty of Arts
Campus Address: 3-98 FAB
Campus Phone number: 492-5092
E-mail address: sadler.takach@ualberta.ca

Part III: Visual communication design student focus group session

Introduction

You are invited to participate in a research project being conducted at the Department of Art and Design, University of Alberta.

The objective of the thesis research is to build an open framework that can serve as a learning aid for design students working on and with diagrams. The framework will take the shape of an interactive computer-supported tool enabling a multivariate management of collected examples of diagrams. Through interaction with the proposed framework, students will be able:
a) to gain an overall view of the possibilities of diagrammatic language;
b) to increase their analytic abilities; and
c) to apply knowledge through practical exercises.

Your role will be to take part in a focus group discussion related to the question how can an analytic framework for the study of diagrams be developed as an educational resource for visual communication design students.

The paper prototype will be presented asking to comment on the proposed solution, the concept of the framework, expected benefits from using the framework and the most suitable features of its interface.

The session will take approximately 20 minutes to complete.

This research is being conducted by Piotr Michura, a Master of Design candidate in Visual Communication Design program, and a research assistant.

Because the nature of focus groups requires discussion with others in a face-to-face situation, complete anonymity is not possible. However, all focus group participants will be asked not to share the content of others' comments outside the focus group meeting.

The focus group discussion will be tape-recorded and transcribed. After removing any identifying information, these transcripts will be assigned an arbitrary code number to ensure your anonymity. Also, when reports of this research are presented in the MDes thesis report, and possibly in related papers and presentations, we may quote directly from these transcripts but only in a manner that maintains your anonymity.

Your confidentiality and rights

The researcher and assistant associated with this project will comply with the University of Alberta Standards for the Protection of Human Research Participants. Data recorded in the course of this research will be available only to myself, my supervisor, and my research assistant who has signed confidentiality agreement. This study has been reviewed and approved by the University of Alberta Faculty of Arts, Science & Law Research Ethics Board.

I, (please print your name).....acknowledge, understand, and agree to all the following listed:
- I have been asked to participate in a research study.
- My participation in this study is voluntary.

- I have the right to withdraw from this study at any time, without penalty. If I opt out, the data collected in my interview will not be used in the study.
- I have the right to privacy, anonymity and confidentiality.
- All my information will remain confidential.
- My name and personal information will not appear on any materials.
- I may be quoted directly in the MDes thesis report, and possibly in related papers and presentations, although in a way that maintains my anonymity.
- I have the right to have any data collected in this study kept in a safe, secure place.

---------- ----------

Signature of the participant Date

If you have any concerns about this research project, please contact:

Piotr Michura, MDes Candidate
Visual Communication Design
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Campus Address: 3-98 FAB
Campus Phone number: 492-5092
E-mail address: sadler.takach@ualberta.ca

IV. Protocols

Part I: Researcher, practitioner, and educator interview

Introduction

My name is Piotr Michura. I am a graduate student in Visual Communication Design program at the Department of Art and Design, working on my thesis research.

The objective of the thesis research is to build an open framework that can serve as a computer--based learning aid for design students working on and with diagrams. This will help the students to gain an overall view of the possibilities of diagrammatic language, increase their analytic abilities, and use efficiently the knowledge in practical exercises.

This semi-structured interview will consist of questions about formal and informal visual representations used within an academic scene and outside of it in your field of expertise.

I will invite you to explore verbally your working processes, identify and reflect on visual means used for producing and sharing knowledge – traditions, current conventions, and purposes of diagrams being used within your field. I will present an initial concept of the framework to get to know what are the desired features of the framework and anticipated benefits in the context of your field of expertise.

Please, read the consent form now.

Interview questions:

Can you briefly outline the scope of your current research?
Do you use any diagrammatic representations in your current research?
What is the purpose of using diagrams in your current research?
What are the benefits from using diagrams in your research compared to other kinds of visuals?
Do you think it is common to utilize diagrams within your discipline?
Could you show any examples?
Could you describe the context of their use?
Regarding the examples, are diagrams valuable means of communication?
What kind of strategies do you use when you have to prepare, analyze or understand a diagram connected to your field of study?

[the initial framework is introduced]

Do you think that my proposed framework would be of any use for you when working on /with diagrams?
In which ways do you think it could be useful?
What kind of media would be the best carrier for that kind of resource as the proposed framework?
What features should the framework have that would facilitate your work on diagrams?
What would be the strategies you use to work with the framework in the most efficient way?

Part II: Visual communication design instructor focus group session

Introduction

Hello everyone. My name is Piotr Michura. I am a graduate student in Visual Communication Design program at the Department of Art and Design, working on my thesis research.

The objective of the thesis research is to build an open framework that can serve as a computer--based learning aid for design students working on and with diagrams. This will help the students to gain an overall view of the possibilities of diagrammatic language, increase their analytic abilities, and use efficiently the knowledge in practical exercises.

I will present a paper prototype asking to comment on the proposed solution, the concept of the framework, expected benefits from using the framework and the most suitable features of its interface. I am interested in how the framework could fit into broader context of teaching practice, curriculum, assignments, and other learning resources currently being used in classes. It would be of special importance to consult with you possible scenarios of instructions involving active use of the proposed framework.

The entire session will take approximately 20 minutes to complete.

Please, read the consent form now.

Focus group questions:

Can each of you briefly outline the objectives of courses you teach?
Do the course programs include teaching about diagrams in particular?
How do you approach this topic – from mostly theoretical or practical point of view?
Should the students be provided with a broad theoretical overview while working on specific task involving a creation of diagrams?
Can you tell me about any particular task or assignment in which students were obliged to use diagrams in a final solution?

[the framework is introduced]

Can you envision that my proposed framework would be helpful for them in this particular task or assignment?
What kind of media would be the best carrier for that kind of resource as the proposed framework?
Would you provide the student with any particular way of use of the framework?
What way would it be?
What features should the framework have that would facilitate your teaching?
Can you imagine how you can involve the framework in your current teaching practice?
What assignment would take the full advantage of the framework as an educational resource?
Could you propose the topic?

Part III: Visual communication design student focus group session

Introduction

Hello everyone. My name is Piotr Michura. I am a graduate student in Visual Communication Design program at the Department of Art and Design, working on my thesis research.

The objective of the thesis research is to build an open framework that can serve as a computer--based learning aid for design students working on and with diagrams. This will help the students to gain an overall view of the possibilities of diagrammatic language, increase their analytic abilities, and use efficiently the knowledge in practical exercises.

I will present a paper prototype asking to comment on the proposed solution, the concept of the framework, expected benefits from using the framework and the most suitable features of its interface. Another aspect of the study would be to find out what is the influence of visual aspects of prototyped framework on the working experience of participants. The main goal is to ensure that the framework meets students' needs.

The entire session will last approximately 20 minutes.

I will now read the consent form, which describes you role and describe your rights as participants. After the consent form has been signed we will start the session.

Please, read the consent form now.

Focus group questions:

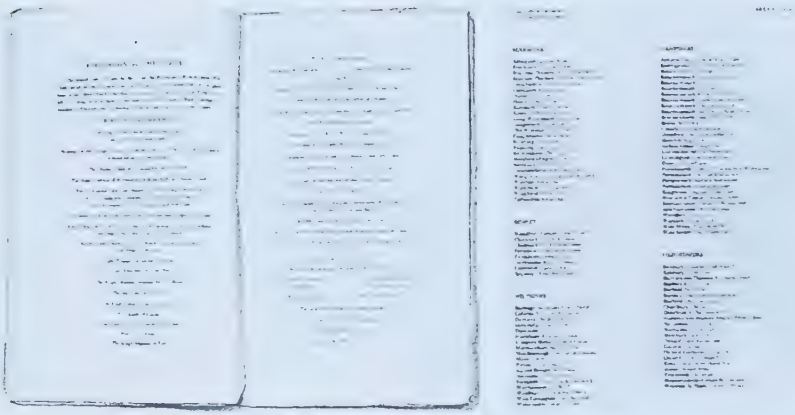
[the framework is introduced]

Imagining the task about designing a diagram for specific use what kind of information would you expect to obtain from such a framework?
What sorts of features should such a framework include?
What activities should the framework allow?

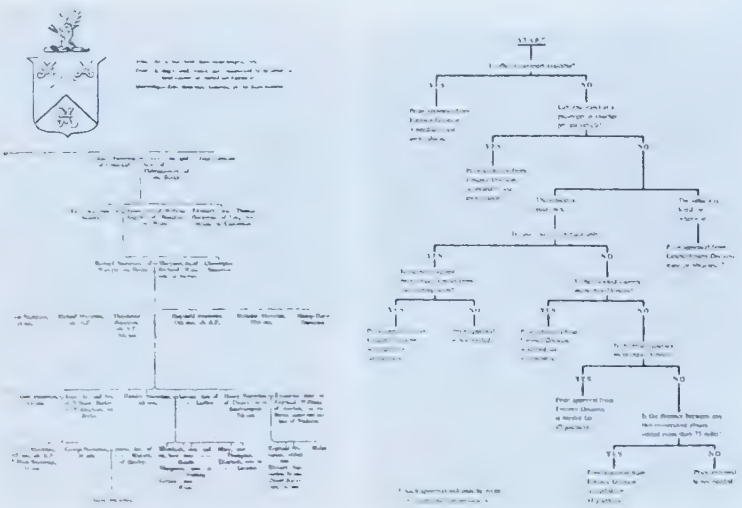
What do you think about overall look of the interface?
Does the design motivate you to use the framework?
Is the content presented clearly?
Is a structure of the underlying organizational principles of the content visible and understandable?
How does the design of the framework respond to the concept of the framework?
What would you change in the design?

Does the interface suggest any particular way of use of the framework?
Imagining the task about designing a diagram for a specific use. How would you approach the problem using the framework?
What sequence of steps would you apply?

Examples from M. Twyman's schema

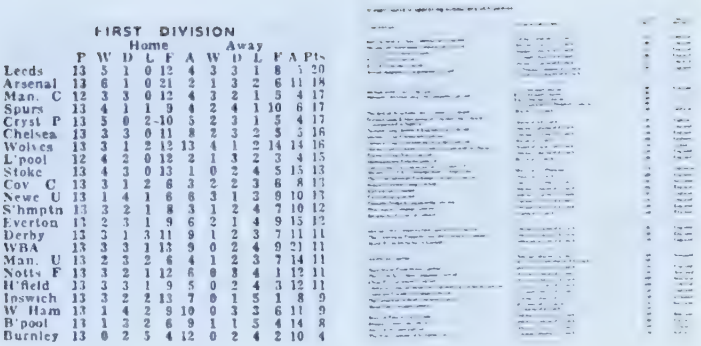


Cell 3. Lists differ from 2 above in that the items presented on each line form discrete semantic units. On the left is the order of the coronation procession of George IV, 1821. On the right is a restaurant guide in which entries are distinguished from one another by occupying separate lines, though each entry consists of two parts which are distinguished from one another typographically.



Cell 4. On the left is a traditional family tree of 1833, with many branches; on the right is an algorithm, which is binary.

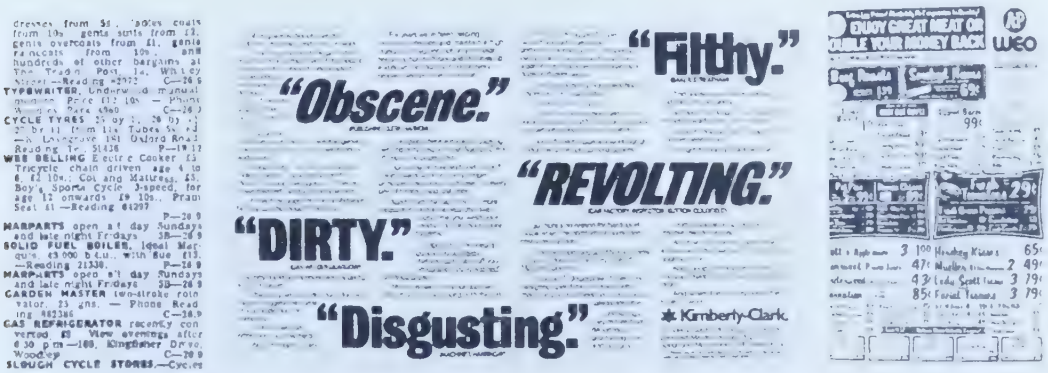
Twyman, M. (1979). A Schema for the Study of Graphic Language. In P. A. Kolers, M. E. Wrolstad, H. Bouma (Eds.), *Processing of Visible Language Vol. 1.* (pp. 117-150). New York: Plenum Press.



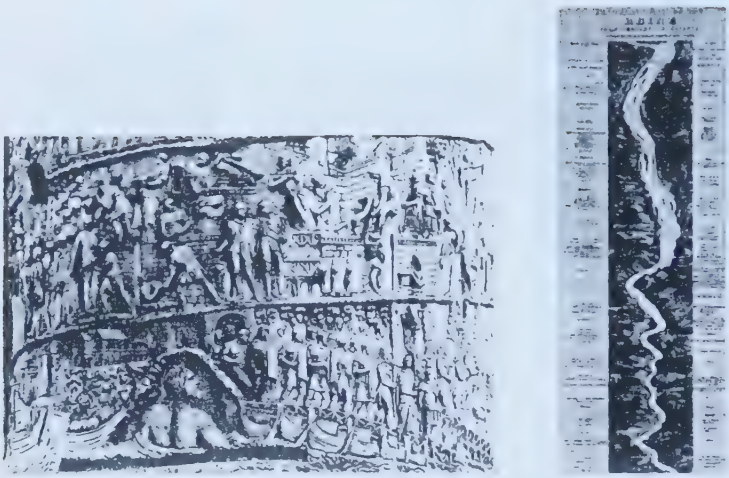
FIRST DIVISION

	Home						Away						
	P	W	D	L	F	A	W	D	L	F	A	Pts
Leeds	13	5	1	0	12	4	3	3	1	8	5	20
Arsenal	13	6	1	0	21	2	1	3	2	6	11	18
Man. C	12	3	3	0	12	4	3	2	1	5	4	17
Spurs	13	4	1	1	9	4	2	4	1	10	6	17
Cryst P	13	5	0	2	10	5	2	3	1	5	4	17
Chelsea	13	3	3	0	11	8	2	3	2	5	5	16
Wolves	13	3	1	2	12	13	4	1	2	14	14	16
L'pool	12	4	2	0	12	2	1	3	2	3	4	15
Stoke	13	4	3	0	13	1	0	2	4	5	15	13
Cov C	13	3	1	2	6	3	2	2	3	6	8	13
Newc U	13	1	4	1	6	6	3	1	3	9	10	13
S'hmptn	13	3	2	1	8	3	1	2	4	7	10	12
Everton	13	2	3	1	9	6	2	1	4	9	15	12
Derby	13	3	1	3	11	9	1	2	3	7	11	11
WBA	13	3	3	1	13	9	0	2	4	9	21	11
Man. U	13	2	3	2	6	4	1	2	3	7	14	11
Notts F	13	3	2	1	12	6	0	3	4	1	12	11
H'field	13	3	3	1	9	5	0	2	4	3	12	11
Ipswich	13	3	2	2	13	7	0	1	5	1	8	9
W Ham	13	1	4	2	9	10	0	3	3	6	11	9
B'pool	13	1	2	2	6	9	1	1	5	4	14	8
Burnley	13	0	2	5	4	12	0	2	4	2	10	4

Cell 5. Both these matrices would be described as tables: the football league table (left) is primarily numerical, the page from a company report (right) is primarily verbal.



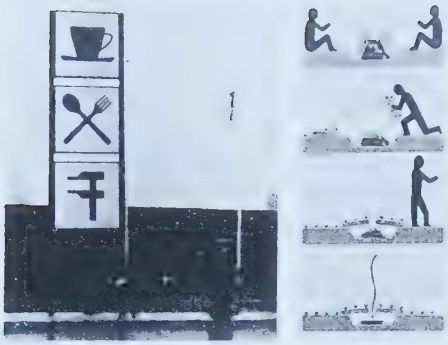
Cell 6. The boundary between Cells 6 and 7 is subjectively drawn. "Non-linear directed" has traditionally been the language of advertising. Examples shown range from a consistent method of directing the viewing (left), where it is assumed that the bold headings will be scanned vertically as a first operation, to others (centre and right) where it is most unlikely that reading strategies will bear much relation to those adopted in relation to "linear interrupted" language.



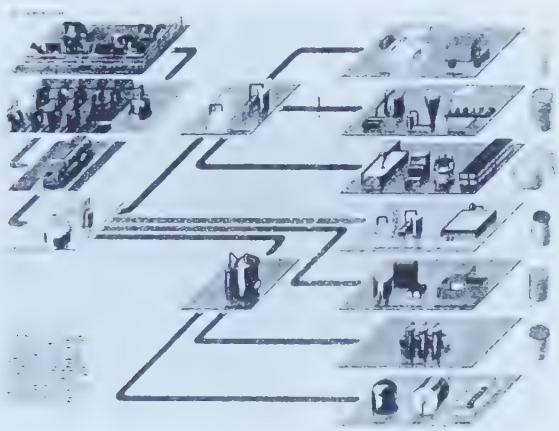
Cell 15. The story in relief sculpture spiralling up Trajan's Column of 112AD in Rome (left), and panoramic views of coastlines and rivers (right) are examples of the linear presentation of pictures.

Cell 16. Wall paintings and mosaics have traditionally been presented in series of discrete scenes. The individual scenes of Giotto's fresco cycle in the Scrovegni Chapel, Padua (left and centre) of the early fourteenth century have been arranged, in so far as the structure of the building will allow, in much the same way as one reads text. A closer parallel with the "verbal/-numerical" mode is provided by the illustration of the funeral procession of Lord Nelson, 1806 (right) in which the rows of pictures have been "justified" by putting variable amounts of space between the pictorial units.

Twyman, M. (1979). A Schema for the Study of Graphic Language. In P. A. Kolers, M. E. Wrolstad, H. Bouma (Eds.), *Processing of Visible Language Vol. 1*. (pp. 117-150). New York: Plenum Press.



Cell 17. Amongst the simplest pictorial lists are arrays of symbols designed to facilitate international travel (left). A more complicated example is provided by the sequence of pictures (right), each of which represents a separate stage in the narrative.



Cell 18. This pictorial tree from a recently published pictorial encyclopaedia illustrates the structure of the dairy industry. The original is colour coded.

Final visual presentation

Piotr Michura

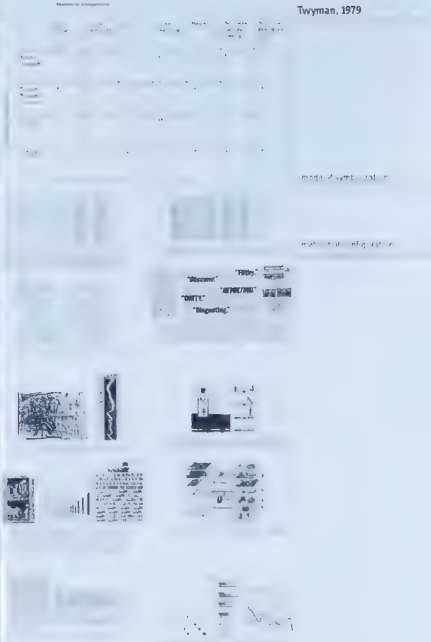
Designing an open framework for creating, using and studying diagrammatic representations

Master's thesis project
Visual Communication Design
Department of Art & Design
University of Alberta

Supervisor: Bonnie Sadler Takach

The objective of the research was to develop an open framework that could serve as an aid for creating, using and studying diagrammatic representations.

An overview of approaches to study diagrammatic representations in relevant literature is presented, followed by a series of interviews with experts from different disciplines talking about their understanding of issues connected to diagrams. As a result, the concept of diagrammaticity is introduced, which is a working term encapsulating circumstances that can contribute to diagrammatic qualities of visual representation. Finally the framework is proposed based on an aspect-factors schema, which is an attempt to operationalize the diagrammaticity concept. The framework consists of aspects, which offer means for description how diagrammatic representation works, and factors, which structure information about the situational context in which the representation is involved.



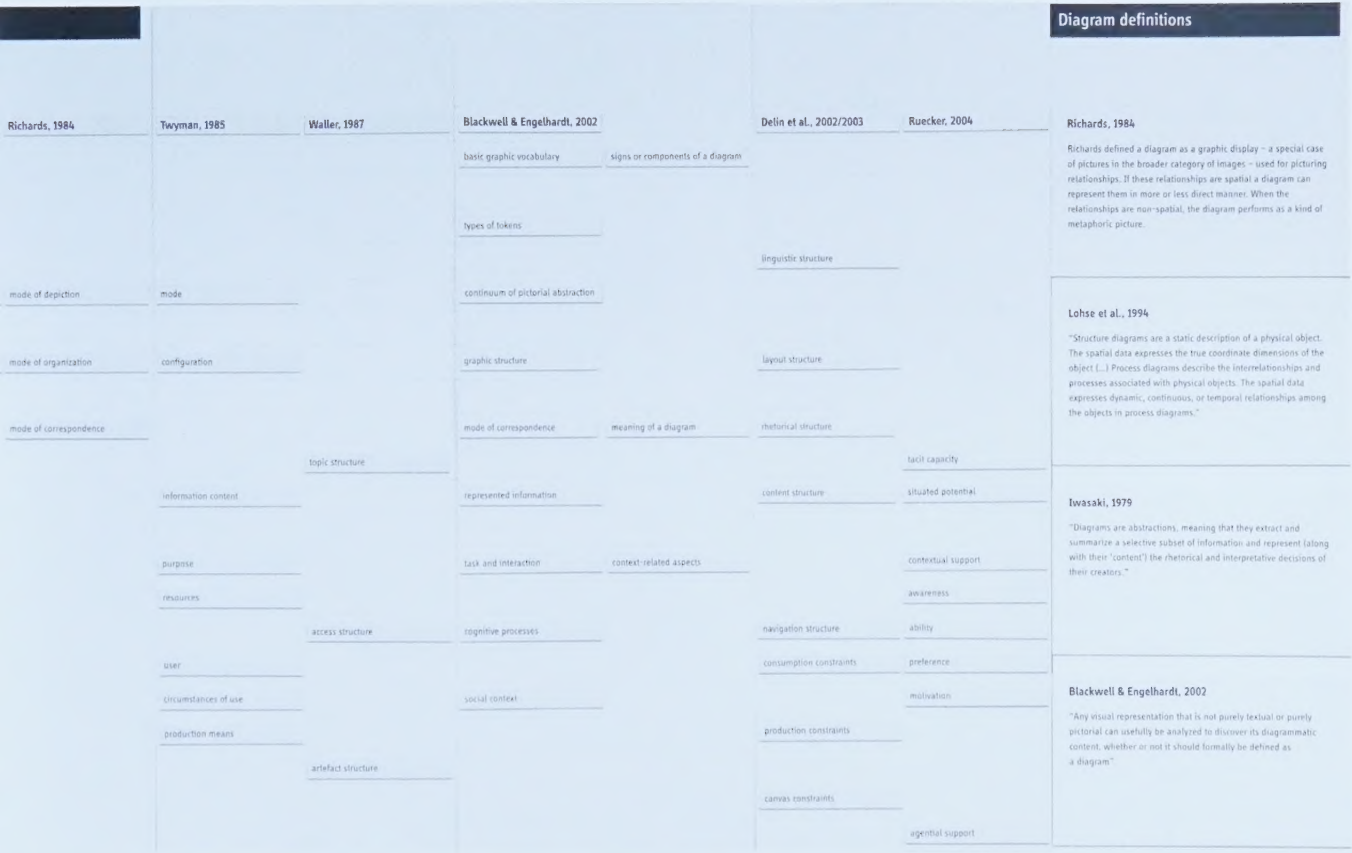


Diagram definitions

Richards, 1984

Richards defined a diagram as a graphic display – a special case of pictures in the broader category of images – used for picturing relationships. If these relationships are spatial a diagram can represent them in more or less direct manner. When the relationships are non-spatial, the diagram performs as a kind of metaphoric picture.

Lohse et al., 1994

"Structure diagrams are a static description of a physical object. The spatial data expresses the true coordinate dimensions of the object (...) Process diagrams describe the interrelationships and processes associated with physical objects. The spatial data expresses dynamic, continuous, or temporal relationships among the objects in process diagrams."

Iwasaki, 1979

"Diagrams are abstractions, meaning that they extract and summarize a selective subset of information and represent (along with their 'content') the rhetorical and interpretative decisions of their creators."

Blackwell & Engelhardt, 2002

"Any visual representation that is not purely textual or purely pictorial can usefully be analyzed to discover its diagrammatic content, whether or not it should formally be defined as a diagram".

The framework

- representation
- user
- task
- context

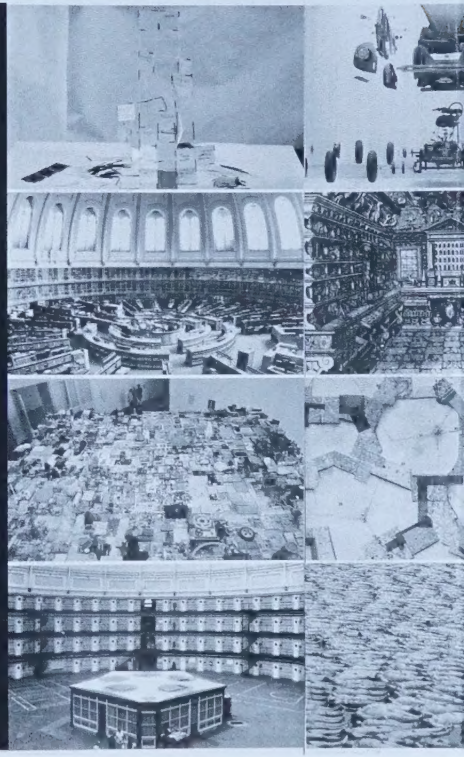
Factors

- information content
- rhetorical methods
- stylistic/aesthetic characteristics
- configuration
- navigation/traversal
- language used
- artefactual dimension
- appropriateness
- awareness
- motivation
- abilities
- preference
- expectancy
- purpose
- goals
- problems, sub-tasks
- means, form of outcomes
- idiosyncrasies of the subject area
- facilities, presence of means
- time
- agential influences
- alternatives

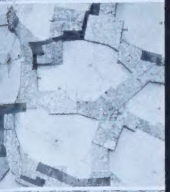
Aspects

- emergence in visual representation
- generative function of negative spaces
- analogical character of representation
- constrained analogy
- over-specificity
- degree of particularization
- self-consistency
- nomic constraints
- visual rhetoric
- adaptability
- directness
- iconicity strategies, non-arbitrariness
- reductivity
- compressed and inclusive
- conventional
- localized organization for apprehension of information
- spatial
- hybrid
- simultaneous display of elements

Diagrammaticity



Example application of the framework



What makes a visual representation diagrammatic? How can diagrammatic tendencies in visual representation be supported or assisted? By what? In which circumstances?

To explore these questions, it was useful to devise a working concept, which could direct the labeling the complexity of diagrammatic qualities of visual representations. This referred to interrelations between aspects and factors of overall situation, leading to possibly exhaustive description of conditions that enable diagrammatic qualities of representation to emerge. The proposed concept of diagrammaticity embraces aspects of the way visual representation works, determining its diagrammatic character, and situational factors, which condition the emergence of the aspects.

Diagrammaticity is a possible state of affairs involving visual representation, and is specified in relation to parameters of situation in which visual representation is involved. Diagrammaticity is not an absolute characteristic of any representation. It is relative and stems from a variety of aspects of a considered situation. Diagrammacity goes beyond definite articulation of what a diagram is. Instead it emphasizes the circumstances that enable diagrammatic communication to take place.It is important to think of diagrams not as a distinct type of graphic representation, but as a feature referring to a more or less strong inclination of visual representations towards specific characteristics.

Developing a concept of diagrammaticity was an attempt to provide with language, that could account for diagrammatic advantages of visual representations, and establish common set of terms. The core of the concept is a set of aspects, present or potential, capable of being manifested in the appropriate conditions.

Diagrammaticity, from this point of view, may be present at different degrees of intensity and is conditioned by the situation, in which visual representation is perceived. Diagrammaticity points to any visual representation as potentially capable to hold diagrammatic communication, encompassing latent or emerging diagrammatic properties of visual representation. The concept of diagrammaticity helps to answer the question about any given representation "how diagrammatic is it?" instead of "is it diagrammatic?"